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Technical Reference

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Revised Edition (April 1984)

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CAUTION
The product described herein is equipped with a grounded plug for the user's safety. It is to be used in conjunction with a properly grounded receptacle to avoid electrical shock.

Preface

This publication describes the various units of the IBM Personal Computer; and the interaction of each.

The information in this publication is for reference, and is intended for hardware and program designers, programmers, engineers, and anyone else with a knowledge of electronics and/or programming who needs to understand the design and operation of the IBM Personal Computer.

This publication consists of two parts: a system manual and an options and adapters manual.

The system manual is divided into the following sections:

Section 1, "System Board," discusses the component layout, circuitry, and function of the system board.

Section 2, "Coprocessor," describes the Intel 8087 coprocessor and provides programming and hardware interface information.

Section 3, "Power Supply," provides electrical input/output specifications as well as theory of operation for the IBM Personal Computer power supply.

Section 4, "Keyboard," discusses the hardware make up, function, and layout of the IBM Personal Computer keyboard.

Section 5, "System BIOS," describes the basic input/output system and its use. This section also contains the software interrupt listing, a BIOS memory map, descriptions of vectors with special meanings, and a set of low memory maps. In addition, keyboard encoding and usage is discussed.

Section 6, "Instruction Set," provides a quick reference for the 8088 assembly instruction set.

Section 7, "Characters, Keystrokes, and Colors," supplies the decimal and hexadecimal values for characters and text attributes.

Section 8, "Communications," describes communications hardware and discusses communications interface standards and the sequence of events to establish communications.

A glossary, bibliography, and index are also provided.

The options and adapters manual provides information, logic diagrams, and specifications pertaining to the options and adapters available for the IBM Personal Computer family of products. The manual is modular in format, with each module providing information about a specific option or adapter. Modules having a large amount of text contain individual indexes. The modules are grouped by type of device into the following categories:

- Expansion Unit
- Displays
- Printers
- Storage Devices
- Memory Expansion
- Adapters
- Miscellaneous
- Cables and Connectors

Full page length hard tabs with the above category descriptions, separate the groups of modules.

The term "*Technical Reference* manual" in the option and adapter manual, refers to the IBM Personal Computer *Technical Reference* system manual.

The term "*Guide to Operations* manual" in the option and adapter manual, refers to the IBM Personal Computer *Guide to Operations* manual.

Prerequisite Publications

- IBM Personal Computer *Guide to Operations*

Suggested Reading

- *BASIC for the IBM Personal Computer*
- *Disk Operating System (DOS)*, Version 1.1
- *Disk Operating System (DOS)*, Version 2.1
- IBM Personal Computer *Hardware Maintenance and Service*
- *MACRO Assembler for the IBM Personal Computer*

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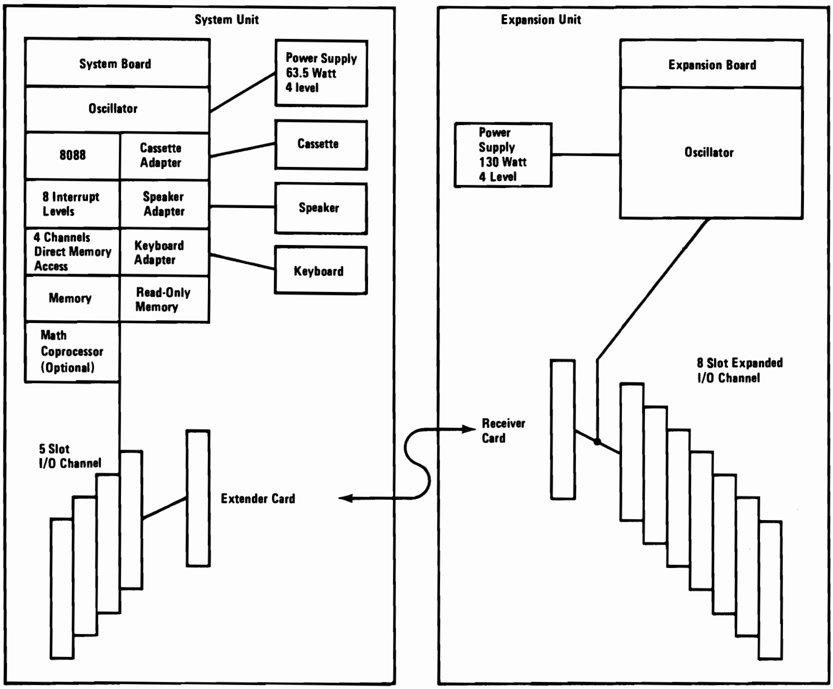
System Block Diagram

The following is a system block diagram of the IBM Personal Computer.



Note: A "System to Adapter Compatibility Chart," to identify the adapters supported by each system, and an "Option to Adapter Compatibility Chart," to identify the options supported by each adapter, can be found in the front matter of the *Technical Reference* options and adapters manual, Volume 1.

SECTION 1. SYSTEM BOARD

Contents

Description

The system board fits horizontally in the base of the system unit and is approximately 215.5 mm (8-1/2 in.) x 304.8 mm (12 in.). It is a multilayer, single-land-per-channel design with ground and internal planes provided. Dc power and a signal from the power supply enter the board through two six-pin connectors. Other connectors on the board are for attaching the keyboard, audio cassette and speaker. Five 62-pin card edge-sockets are also mounted on the board. The I/O channel is bussed across these five I/O slots.

Two dual-in-line package (DIP) switches (two eight-switch packs) are mounted on the board and can be read under program control. The DIP switches provide the system software with information about the installed options, how much storage the system board has, what type of display adapter is installed, what operation modes are desired when power is switched on (color or black-and-white, 80 or 40-character lines), and the number of diskette drives attached.

The system board consists of five functional areas: the microprocessor subsystem and its support elements, the read-only memory (ROM) subsystem, the read/write (R/W) memory subsystem, integrated I/O adapters, and the I/O channel. The read/write memory is also referred to as random access memory (RAM). All are described in this section.

Microprocessor

The heart of the system board is the Intel 8088 Microprocessor. This is an 8-bit external-bus version of Intel's 16-bit 8086 Microprocessor, and is software-compatible with the 8086. Thus, the 8088 supports 16-bit operations, including multiply and divide, and supports 20 bits of addressing (1 megabyte of storage). It also operates in maximum mode, so a comicroprocessor can be added as a feature. The microprocessor operates at 4.77-MHz. This frequency, which is derived from a

14.31818-MHz crystal, is divided by 3 for the microprocessor clock, and by 4 to obtain the 3.58-MHz color burst signal required for color televisions.

At the 4.77-MHz clock rate, the 8088 bus cycles are four clocks of 210-ns, or 840-ns. I/O cycles take five 210-ns clocks or 1.05-μs.

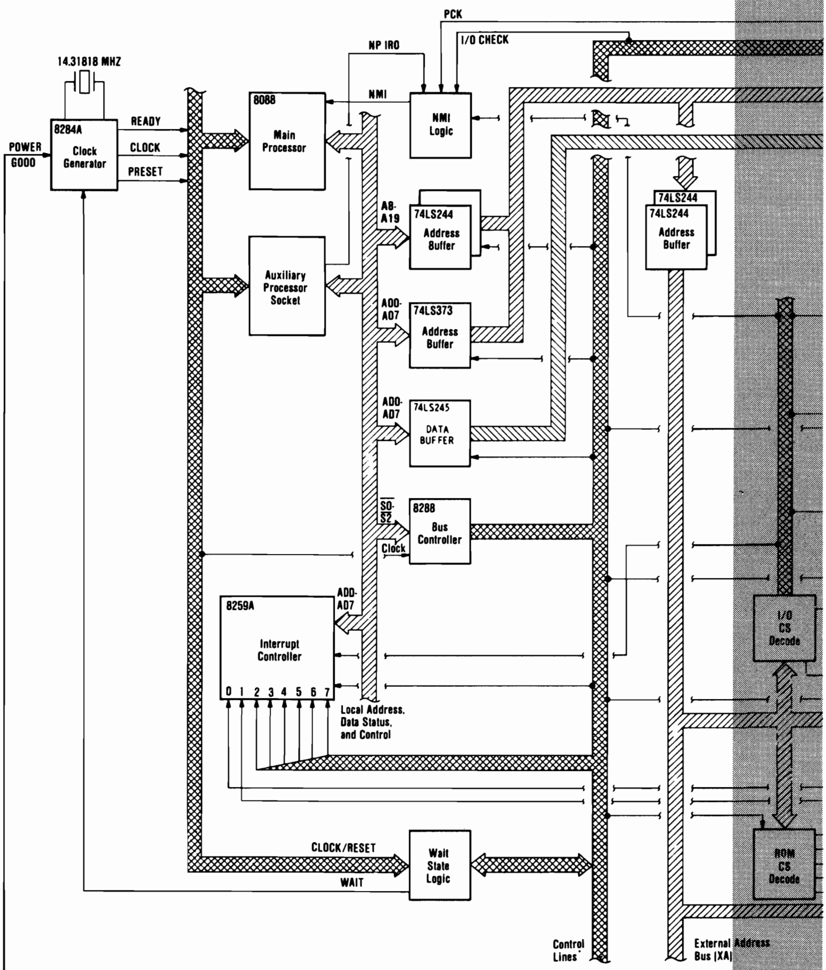
The system board contains circuits for attaching an audio cassette, the keyboard, and the speaker. The cassette adapter allows the attachment of any good quality audio cassette through the earphone output and either the microphone or auxiliary inputs. The system board has a jumper for either input. This interface also provides a cassette motor control for transport starting and stopping under program control. This interface reads and writes the audio cassette at a data rate of between 1,000 and 2,000 baud. The baud rate is variable and depend on data content, because a different bit-cell time is used for 0's and 1's. For diagnostic purposes, the tape interface can loop read to write for testing the system board's circuits. The ROM cassette software blocks cassette data and generates a cyclic redundancy check (CRC) to check this data.

The system board contains the adapter circuits for attaching the serial interface from the keyboard. These circuits generate an interrupt to the microprocessor when a complete scan code is received. The interface can request execution of a diagnostic test in the keyboard.

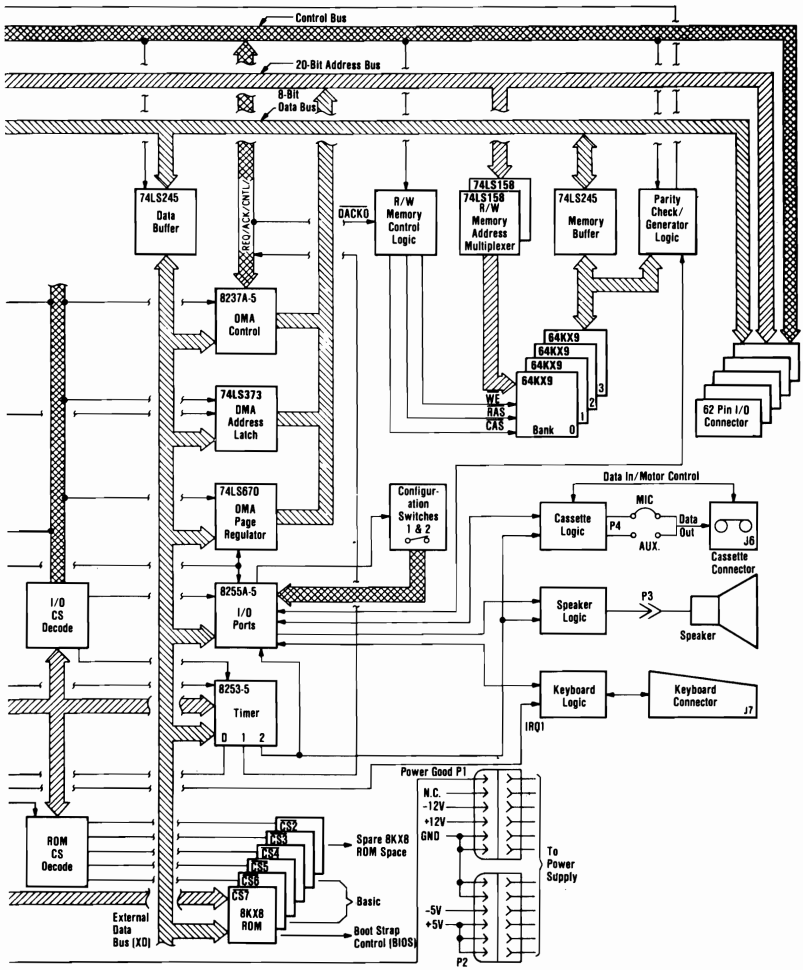
Both the keyboard and cassette interfaces on the system board are 5-pin DIN connectors that extends through the rear panel of the system unit.

Data Flow Diagrams

The following pages contain the system-board Data Flow Diagrams.



System Board Data Flow (1 of 2)



System Board Data Flow (2 of 2)

System Memory Map

The following pages contain the System Memory Map.

Start Address Decimal	Start Address Hex	Function
0	00000	64 to 256K Read/Write Memory on System Board
16K	04000	
32K	08000	
48K	0C000	
64K	10000	
80K	14000	
96K	18000	
112K	1C000	
128K	20000	
144K	24000	
160K	28000	
176K	2C000	
192K	30000	
208K	34000	
224K	38000	
240K	3C000	
256K	40000	Up to 384K Read/Write Memory in I/O Channel
272K	44000	
288K	48000	
304K	4C000	
320K	50000	
336K	54000	
352K	58000	
368K	5C000	
384K	60000	
400K	64000	
416K	68000	
432K	6C000	
448K	70000	
464K	74000	
480K	78000	
496K	7C000	
512K	80000	
528K	84000	
544K	88000	
560K	8C000	
576K	90000	
592K	94000	
608K	98000	
624K	9C000	

System Memory Map for 64/256K System Board (Part 1 of 2)

Start Address Decimal	Hex	Function
640K	A0000	128K Reserved
656K	A4000	
672K	A8000	
688K	AC000	
704K	B0000	Monochrome
720K	B4000	
736K	B8000	Color/Graphics
752K	BC000	
768K	C0000	192K Read Only Memory Expansion and Control
784K	C4000	
800K	C8000	Fixed Disk Control
816K	CC000	
832K	D0000	
848K	D4000	
864K	D8000	
880K	DC000	
896K	E0000	
912K	E4000	
928K	E8000	
944K	EC000	
960K	F0000	Reserved
976K	F4000	48K Base System ROM
992K	F8000	
1008K	FC000	

System Memory Map for 64/256K System Board (Part 2 of 2)

System Timers

Three programmable timer/counters are used by the system as follows: Channel 0 is a general-purpose timer providing a constant time base for implementing a time-of-day clock, Channel 1 times and requests refresh cycles from the Direct Memory Access (DMA) channel, and Channel 2 supports the tone generation for the speaker. Each channel has a minimum timing resolution of 1.05-μs.

System Interrupts

Of the eight prioritized levels of interrupt, six are bussed to the system expansion slots for use by feature cards. Two levels are used on the system board.

Level 0, the highest priority, is attached to Channel 0 of the timer/counter and provides a periodic interrupt for the time-of-day clock.

Level 1 is attached to the keyboard adapter circuits and receives an interrupt for each scan code sent by the keyboard. The non-maskable interrupt (NMI) of the 8088 is used to report memory parity errors.

Number	Usage
NMI	Parity
	8087
0	Timer
1	Keyboard
2	Reserved
3	Asynchronous Communications (Alternate)
	SDLC Communications
	BSC Communications
	Cluster (Primary)
4	Asynchronous Communications (Primary)
	SDLC Communications
	BSC Communications
5	Fixed Disk
6	Diskette
7	Printer
	Cluster (Alternate)

8088 Hardware Interrupt Listing

ROM

The system board supports both Read Only Memory (ROM) and Random Access Memory (RAM). It has space for up to 512K of ROM or Eraseable Programmable ROM (EPROM). Six module sockets are provided, each of which can accept an 8K or 8 byte device. Five sockets are populated with 40K of ROM. This ROM contains the cassette BASIC interpreter, cassette operating system, power-on selftest, Input/Output (I/O) drivers, dot patterns for 128 characters in graphics mode, and a diskette bootstrap loader. The ROM is packaged in 28-pin modules and has an access time of 250-ns and a cycle time of 375-ns.

RAM

The RAM on the system board is as shown in the following chart.

System Board	Minimum Storage	Maximum Storage	Memory Modules	Soldered (Bank 0)	Pluggable (Bank 1-3)
64/256K	64K	256K	64K by 1 Bit	1 Bank of 9	3 Banks of 9

Memory greater than the system board's maximum is obtained by adding memory cards in the expansion slots. All memory is parity-checked and consists of dynamic 64K by 1 bit chips with an access time of 250-ns and a cycle time of 410-ns.

DMA

The microprocessor is supported by a set of high-function support devices providing four channels of 20-bit direct-memory access (DMA), three 16-bit timer/counter channels, and eight prioritized interrupt levels.

Three of the four DMA channels are available on the I/O bus and support high-speed data transfers between I/O devices and memory without microprocessor intervention. The fourth DMA channel is programmed to refresh the system dynamic memory. This is done by programming a channel of the timer/counter device to periodically request a dummy DMA transfer. This action creates a memory-read cycle, which is available to refresh dynamic storage both on the system board and in the system expansion slots. All DMA data transfers, except the refresh channel, take five microprocessor clocks of 210-ns, or 1.05-μs if the microprocessor ready line is not deactivated. Refresh DMA cycles take four clocks or 840-ns.

The three programmable timer/counter devices are used by the system as follows: Channel 0 is used as a general-purpose timer providing a constant time base for implementing a time-of-day clock; Channel 1 is used to time and request refresh cycles from the DMA channel; and Channel 2 is used to support the tone generation for the speaker. Each channel has a minimum timing resolution of 1.05-us.

Of the eight prioritized levels of interrupt, six are bussed to the system expansion slots for use by feature cards. Two levels are used on the system board. Level 0, the highest priority, is attached to Channel 0 of the timer/counter device and provides a periodic interrupt for the time-of-day clock. Level 1 is attached to the keyboard adapter circuits and receives an interrupt for each scan code sent by the keyboard. The non-maskable interrupt (NMI) of the 8088 is used to report memory parity errors.

I/O Channel

The I/O channel is an extension of the 8088 microprocessor bus. It is, however, demultiplexed, repowered, and enhanced by the addition of interrupts and direct memory access (DMA) functions.

The I/O channel contains an 8-bit bidirectional data bus, 20 address lines, 6 levels of interrupt, control lines for memory and I/O read or write, clock and timing lines, 3 channels of DMA control lines, memory refresh timing control lines, a channel-check line, and power and ground for the adapters. Four voltage levels are provided for I/O cards: +5 Vdc, -5 Vdc, +12 Vdc, and -12 Vdc. These functions are provided in a 62-pin connector with 100-mil card tab spacing.

A 'ready' line is available on the I/O channel to allow operation with slow I/O or memory devices. If the channel's ready line is not activated by an addressed device, all microprocessor-generated memory read and write cycles take four 210-ns clocks or 840-ns/byte. All microprocessor-generated I/O read and write cycles require five clocks for a cycle time of 1.05-μs/byte. All DMA transfers require five clocks for a cycle time of 1.05-μs/byte. Refresh cycles occur once every 72 clocks (approximately 15-μs) and require four clocks or approximately 7% of the bus bandwidth.

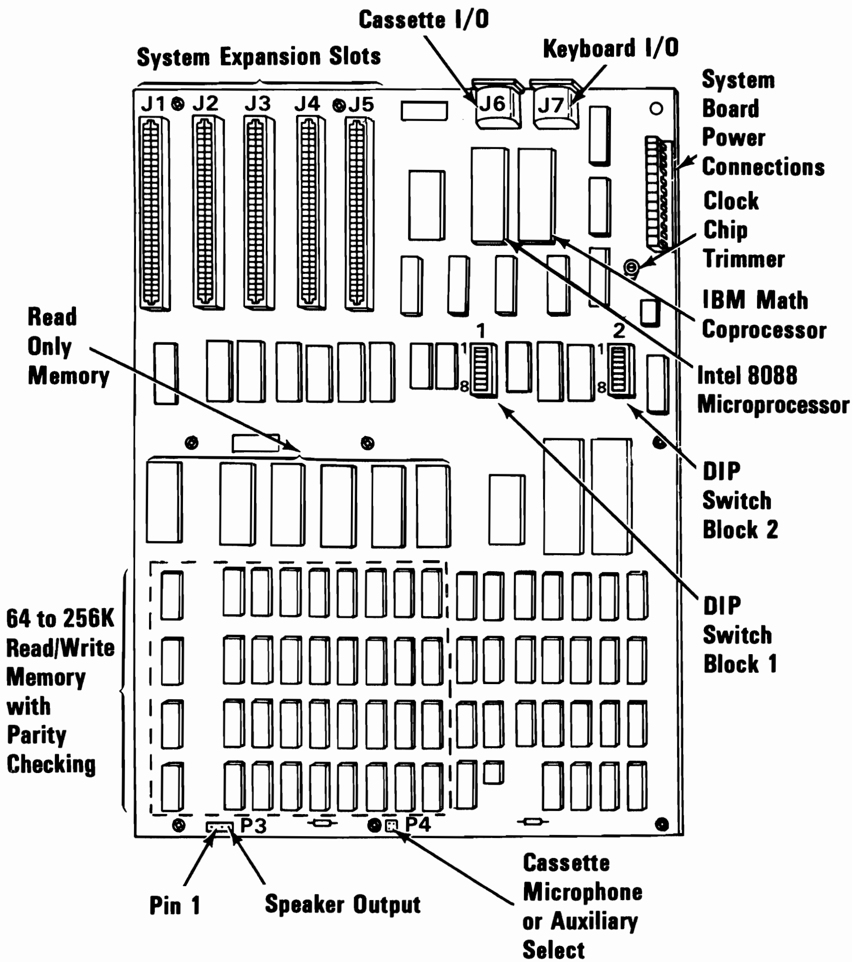
I/O devices are addressed using I/O mapped address space. The channel is designed so that 512 I/O device addresses are available to the I/O channel cards.

A 'channel check' line exists for reporting error conditions to the microprocessor. Activating this line results in a non-maskable interrupt (NMI) to the 8088 microprocessor. Memory expansion options use this line to report parity errors.

The I/O channel is repowered to provide sufficient drive to power all five system unit expansion slots, assuming two low-power Schottky loads per slot. The IBM I/O adapters typically use only one load.

System Board Diagram

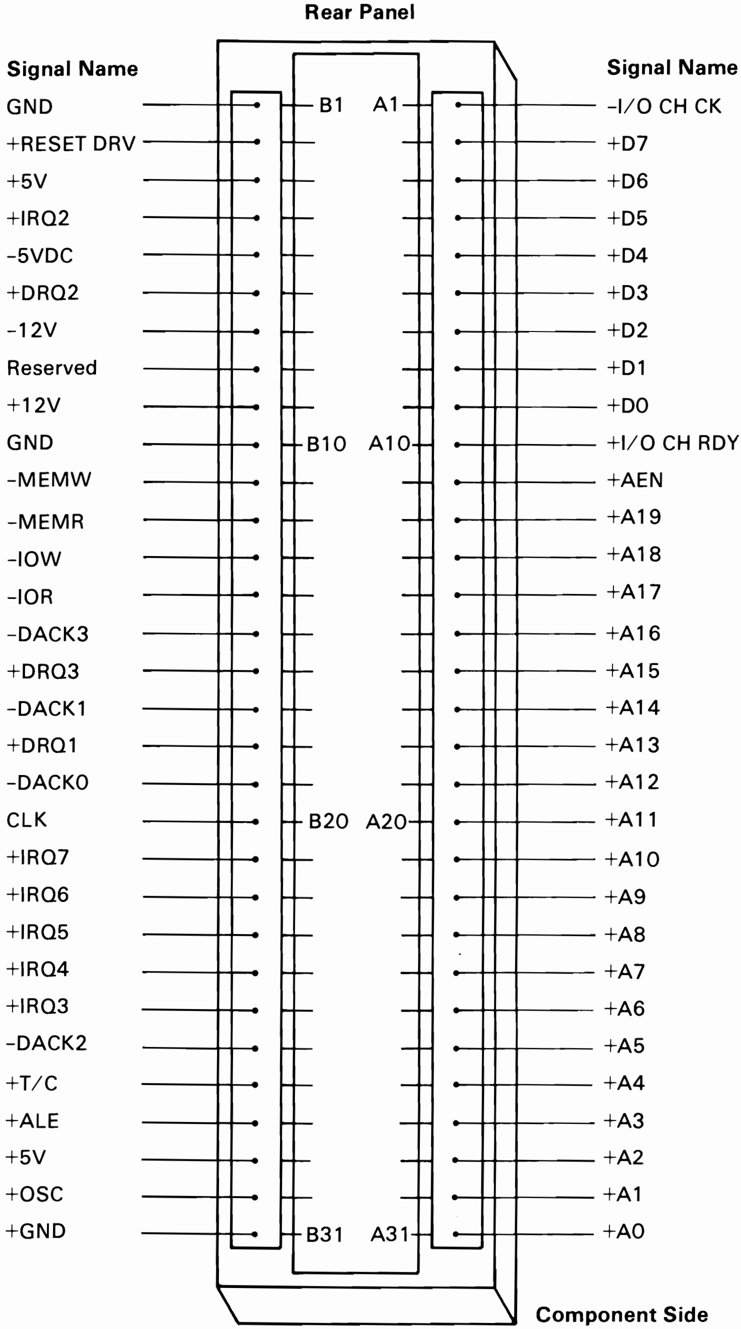
The following shows the system board's component layout.



System Board Component Diagram

I/O Channel Diagram

The following page contains the I/O Channel Diagram. All lines are TTL-compatible.



I/O Channel Diagram

I/O Channel Description

The following is a description of the IBM Personal Computer I/O Channel. All lines are TTL-compatible.

Signal	I/O	Description
A0–A19	O	Address bits 0 to 19: These lines are used to address memory and I/O devices within the system. The 20 address lines allow access of up to 1M-byte of memory. A0 is the least significant bit (LSB) and A19 is the most significant bit (MSB). These lines are generated by either the microprocessor or DMA controller. They are active high.
AEN	O	Address Enable: This line is used to de-gate the microprocessor and other devices from the I/O channel to allow DMA transfers to take place. When this line is active (high), the DMA controller has control of the address bus, data bus, Read command lines (memory and I/O), and the Write command lines (memory and I/O).
ALE	O	Address Latch Enable: This line is provided by the 8288 Bus Controller and is used on the system board to latch valid addresses from the microprocessor. It is available to the I/O channel as an indicator of a valid microprocessor address (when used with AEN). Microprocessor addresses are latched with the falling edge of ALE.
CLK	O	System clock: It is a divide-by-three of the oscillator and has a period of 210-ns (4.77-MHz) The clock has a 33% duty cycle.

D0–D7	**I/O**	Data Bits 0 to 7: These lines provide data bus bits 0 to 7 for the microprocessor, memory, and I/O devices. D0 is the least significant bit (LSB) and D7 is the most significant bit (MSB). These lines are active high.
-DACK0 to -DACK3	**O**	-DMA Acknowledge 0 to 3: These lines are used to acknowledge DMA requests (DRQ1–DRQ3) and refresh system dynamic memory (-DACK0). They are active low.
DRQ1–DRQ3	**I**	DMA Request 1 to 3: These lines are asynchronous channel requests used by peripheral devices to gain DMA service. They are prioritized with DRQ3 being the lowest and DRQ1 being the highest. A request is generated by bringing a DRQ line to an active level (high). A DRQ line must be held high until the corresponding DACK line goes active.
-I/O CH CK	**I**	-I/O Channel Check: This line provides the microprocessor with parity (error) information on memory or devices in the I/O channel. When this signal is active low, a parity error is indicated.
I/O CH RDY	**I**	I/O Channel Ready: This line, normally high (ready), is pulled low (not ready) by a memory or I/O device to lengthen I/O or memory cycles. It allows slower devices to attach to the I/O channel with a minimum of difficulty. Any slow device using this line should drive it low immediately upon detecting a valid address and a Read or Write command. This line should never be held low longer than 10

		clock cycles. Machine cycles (I/O or memory) are extended by an integral number of clock cycles (210-ns).
-IOR	**O**	-I/O Read Command: This command line instructs an I/O device to drive its data onto the data bus. It may be driven by the microprocessor or the DMA controller. This signal is active low.
-IOW	**O**	-I/O Write Command: This command line instructs an I/O device to read the data on the data bus. It may be driven by the microprocessor or the DMA controller. This signal is active low.
IRQ2–IRQ7	**I**	Interrupt Request 2 to 7: These lines are used to signal the microprocessor that an I/O device requires attention. They are prioritized with IRQ2 as the highest priority and IRQ7 as the lowest . An Interrupt Request is generated by raising an IRQ line (low to high) and holding it high until it is acknowledged by the microprocessor (interrupt service routine).
-MEMR	**O**	-Memory Read Command: This command line instructs the memory to drive its data onto the data bus. It may be driven by the microprocessor or the DMA controller. This signal is active low.
-MEMW	**O**	-Memory Write Command: This command line instructs the memory to store the data present on the data bus. It may be driven by the microprocessor or the DMA controller. This signal is active low.

OSC	**O**	Oscillator: High-speed clock with a 70-ns period (14.31818-MHz). It has a 50% duty cycle.
RESET DRV	**O**	Reset Drive: This line is used to reset or initialize system logic upon power-up or during a low line-voltage outage. This signal is synchronized to the falling edge of CLK and is active high.
T/C	**O**	Terminal Count: This line provides a pulse when the terminal count for any DMA channel is reached. This signal is active high.

Hex Range*	Usage
000-00F	DMA Chip 8237A-5
020-021	Interrupt 8259A
040-043	Timer 8253-5
060-063	PPI 8255A-5
080-083	DMA Page Registers
0AX**	NMI Mask Register
200-20F	Game Control
210-217	Expansion Unit
2F8-2FF	Asynchronous Communications (Secondary)
300-31F	Prototype Card
320-32F	Fixed Disk
378-37F	Printer
380-38C***	SDLC Communications
380-389***	Binary Synchronous Communications (Secondary)
390-393	Cluster
3A0-3A9	Binary Synchronous Communications (Primary)
3B0-3BF	IBM Monochrome Display/Printer
3D0-3DF	Color/Graphics
3F0-3F7	Diskette
3F8-3FF	Asynchronous Communications (Primary)
790-793	Cluster (Adapter 1)
B90-B93	Cluster (Adapter 2)
1390-1393	Cluster (Adapter 3)
2390-2393	Cluster (Adapter 4)

* These are the addresses decoded by the current set of adapter cards. IBM may use any of the unlisted addresses for future use.

** At power-on time, the Non Mask Interrupt into the 8088 is masked off. This mask bit can be set and reset through system software as follows:

Set mask: Write hex 80 to I/O Address hex A0 (enable NMI)

Clear mask: Write hex 00 to I/O Address hex A0 (disable NMI)
*** SDLC Communications and Secondary Binary Synchronous Communications cannot be used together because their hex addresses overlap.

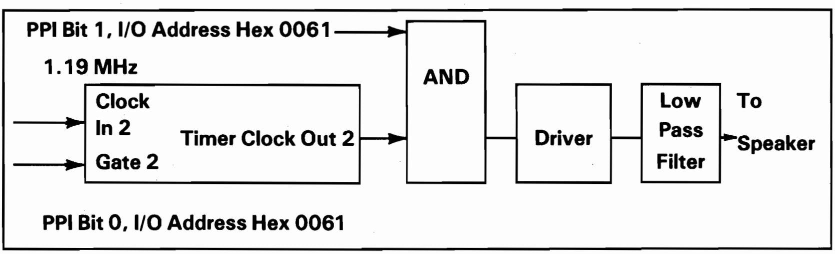
I/O Address Map

Other Circuits

Speaker Circuit

The sound system has a small, permanent magnet, 57.15 mm (2-1/4 in.) speaker. The speaker can be driven from one or both of two sources:

- An 8255A-5 programmable peripheral interface (PPI) output bit. The address and bit are defined in the "I/O Address Map".
- A timer clock channel, the output of which is programmable within the functions of the 8253-5 timer when using a 1.19-MHz clock input. The timer gate also is controlled by an 8255A-5 PPI output-port bit. Address and bit assignment are in the "I/O Address Map".



Speaker Drive System Block Diagram

Channel 2 (Tone generation for speaker)		
	Gate 2	— Controller by 8255A-5 PPI Bit (See I/O Map)
	Clock In 2	— 1.19318 - MHz OSC
	Clock Out 2	— Used to drive speaker

Speaker Tone Generation

The speaker connection is a 4-pin Berg connector. See "System Board Component Diagram," earlier in this section, for speaker connection or placement.

Pin	Function
1	Data
2	Key
3	Ground
4	+5 Volts

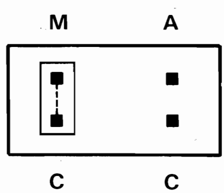
Speaker Connector

The speaker drive circuit is capable of about 1/2 watt of power. The control circuits allow the speaker to be driven three ways: (1) a direct program control register bit may be toggled to generate a pulse train; (2) the output from Channel 2 of the timer/counter device may be programmed to generate a waveform to the speaker; (3) the clock input to the timer/counter device can be modulated with a program-controlled I/O register bit. All three methods may be performed simultaneously.

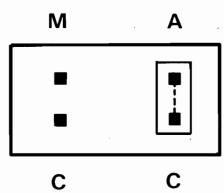
Cassette Interface

The cassette interface is controlled through software. An output from the 8253 timer controls the data to the cassette recorder through pin 5 of the cassette DIN connector at the rear of the system board. The cassette input data is read by an input port bit of the 8255A-5 PPI. This data is received through pin 4 of the cassette connector. Software algorithms are used to generate and read cassette data. The cassette drive motor is controlled through pins 1 and 3 of the cassette connector. The drive motor on/off switching is controlled by an 8255A-5 PPI output-port bit (hex 61, bit 3). The 8255A-5 address and bit assignments are defined in "I/O Address Map" earlier in this section.

A 2 by 2 Berg pin and a jumper are used on the cassette 'data out' line. The jumper allows use of the 'data out' line as a 0.075-Vdc microphone input when placed across the M and C of the Berg Pins. A 0.68-Vdc auxiliary input to the cassette recorder is available when the jumper is placed across the A and C of the Berg Pins. The "System Board Component Diagram" shows the location of the cassette Berg pins.



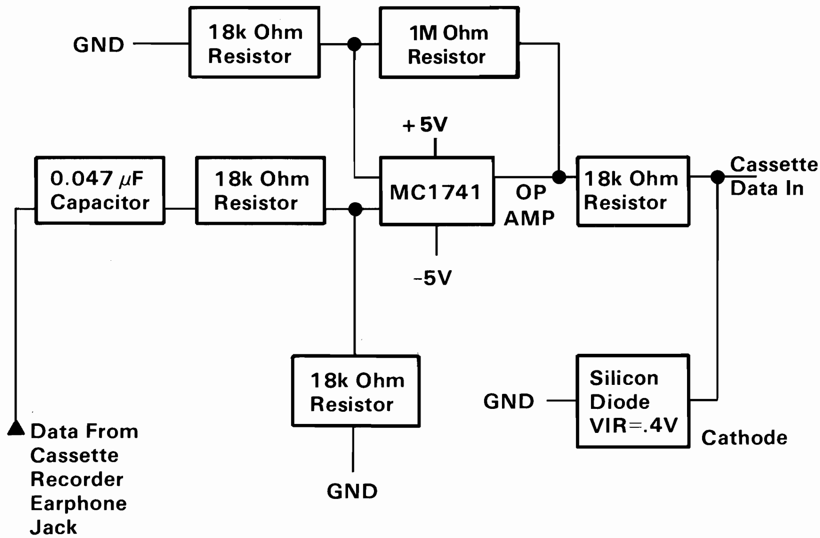
Microphone Input
(0.075 Vdc)



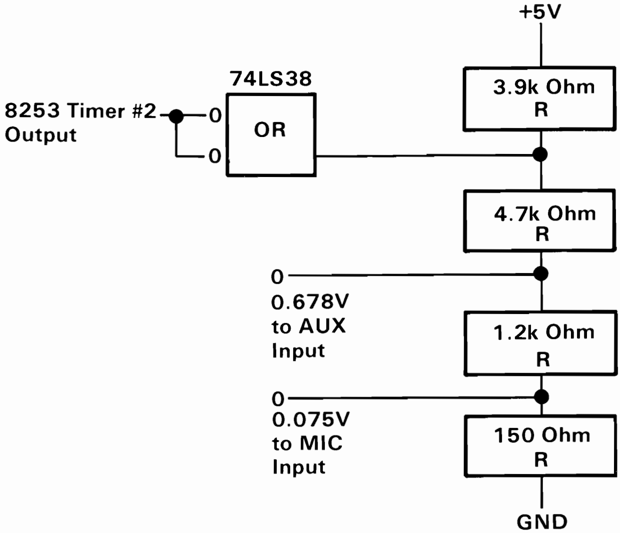
Auxiliary Input
(0.68 Vdc)

Cassette Circuit Block Diagrams

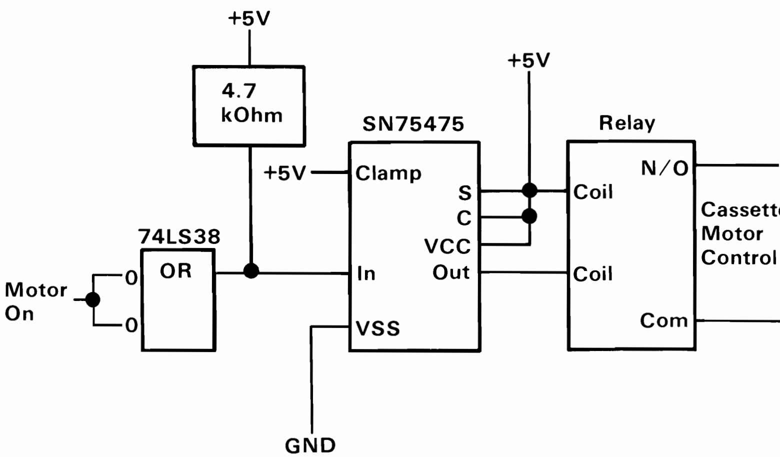
Circuit block diagrams for the cassette-interface read hardware, write hardware, and motor control are illustrated below.



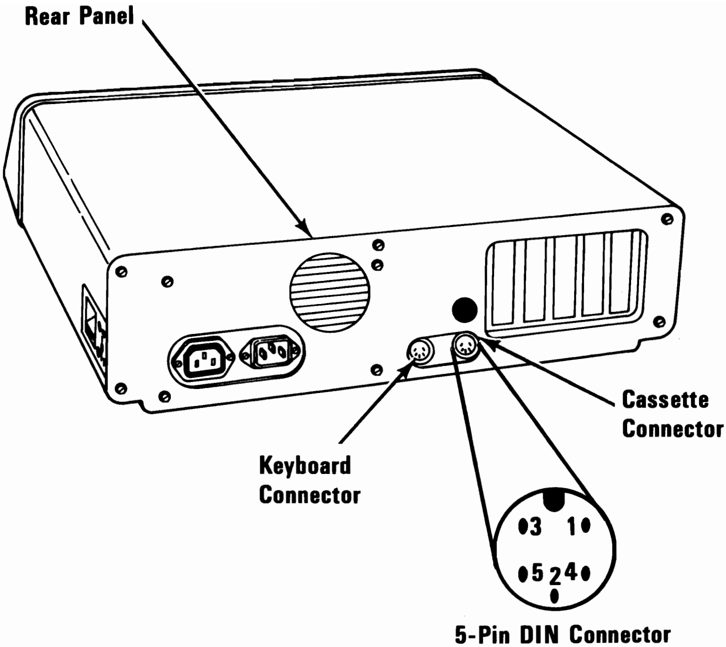
Cassette-Interface Read Hardware Block Diagram



Cassette Interface Write Hardware Block Diagram



Cassette Motor Control Block Diagram



Pin	Signal	Electrical Characteristics
1	Motor Control	Common from Relay
2	Ground	
3	Motor Control	Relay N.O. (6 Vdc at 1A)
4	Data In	500nA at ± 13V - at 1,000 - 2,000 Baud
5	Data Out (Microphone or Auxiliary)	250 µA at 0.68 Vdc or ** 0.075 Vdc

*All voltages and currents are maximum ratings and should not be exceeded.

**Data out can be chosen using a jumper located on the system board. (Auxiliary →0.68 Vdc or Microphone →0.075 Vdc).

Interchange of these voltages on the cassette recorder could lead to damage of recorder inputs.

Cassette Interface Connector Specifications

8255A I/O Bit Map

The 8255A I/O Bit Map shows the inputs and outputs for the Command/Mode register on the system board. Also shown are the switch settings for the memory, display, and number of diskette drives. The following page contains the I/O bit map.

Hex Port Number		Bit				
0060	INPUT	PA0	+ Keyboard Scan Code 0	Or	IPL 5-1/4 Diskette Drive	(SW1 – 1)
		1	1		Reserved	(SW1 – 2)
		2	2		System Board Read/Write Memory Size	*(SW1 – 3)
		3	3		System Board Read/Write Memory Size	*(SW1 – 4)
		4	4		+ Display Type 1	**(SW1 – 5)
		5	5		+ Display Type 2	**(SW1 – 6)
		6	6		No. of 5-1/4 Drives	***(SW1 – 7)
		7	7		No. of 5-1/4 Drives	***(SW1 – 8)
0061	OUTPUT	PB0	+ Timer 2 Gate Speaker			
		1	+ Speaker Data			
		2	+ (Read Read/Write Memory Size) or (Read Spare Key)			
		3	+ Cassette Motor Off			
		4	– Enable Read/Write Memory			
		5	– Enable I/O Channel Check			
		6	– Hold Keyboard Clock Low			
		7	– (Enable Keyboard or + (Clear Keyboard and Enable Sense Switches)			
0062	INPUT	PC0	I/O Read/Write Memory (Sw2 – 1)	Binary Value X 32K	Or	I/O Read/Write Memory (Sw2 – 5)
		1	I/O Read/Write Memory (Sw2 – 2)			
		2	I/O Read/Write Memory (Sw2 – 3)			
		3	I/O Read/Write Memory (Sw2 – 4)			
		4	+ Cassette Data In			
		5	+ Timer Channel 2 Out			
		6	+ I/O Channel Check			
		7	+ Read/Write Memory Parity Check			

0063 Command/Mode Register

Mode Register Value — Hex 99

7	6	5	4	3	2	1	0
1	0	0	1	1	0	0	1

*	PA3 Sw1 – 4	PA2 Sw1 – 3	Amount of Memory Located on System Board
	1	1	64 to 256K

**	PA5 Sw1 – 6	PA4 Sw1 – 5	Display at Power-Up Mode
	0	0	Reserved
	0	1	Color 40 X 25 (BW Mode)
	1	0	Color 80 X 25 (BW Mode)
	1	1	IBM Monochrome (80 X 25)

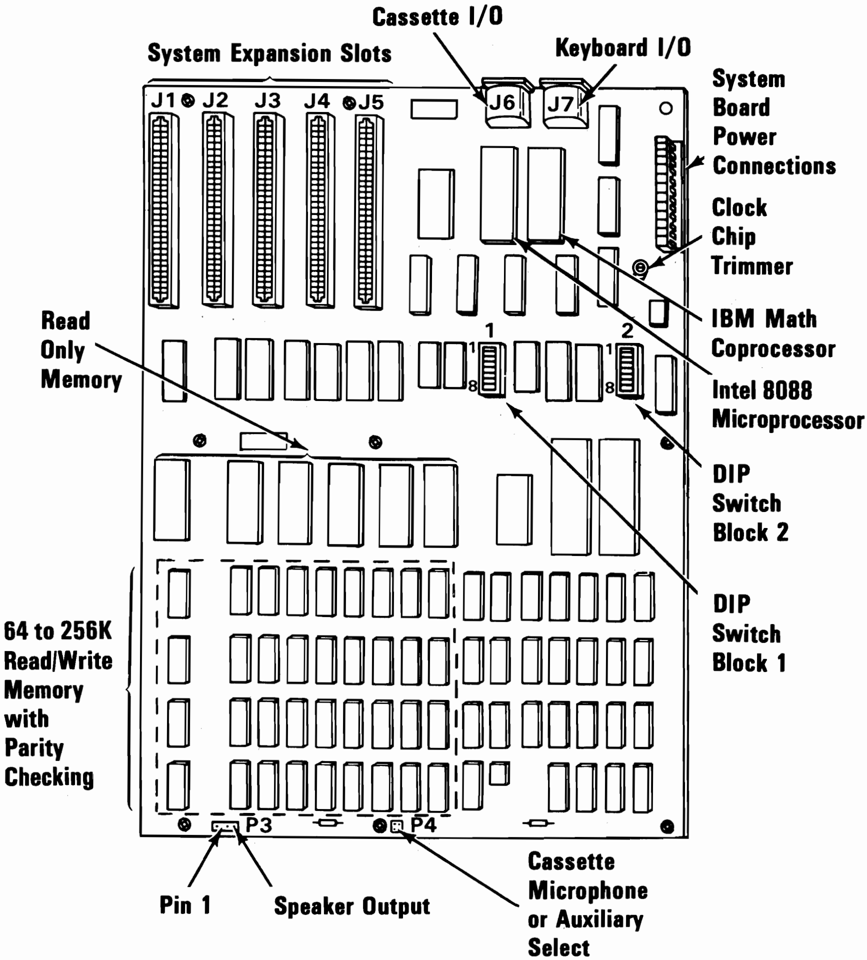
***	PA7 Sw1 – 8	PA6 Sw1 – 7	Number of 5-1/4" Drives in System
	0	0	1
	0	1	2
	1	0	3
	1	1	4

Note: A plus (+) indicates a bit value of 1 performs the specified function.
A minus (–) indicates a bit value of 0 performs the specified function.
PA Bit = 0 implies switch "ON." PA bit = 1 implies switch "OFF."

8255A I/O Bit Map

System-Board Switch Settings

All system board switch settings for total system memory, number of diskette drives, and type of display adapter are described under "Switch Settings" in the IBM Personal Computer *Guide to Operations*. The diagram showing the system board switch locations follows.



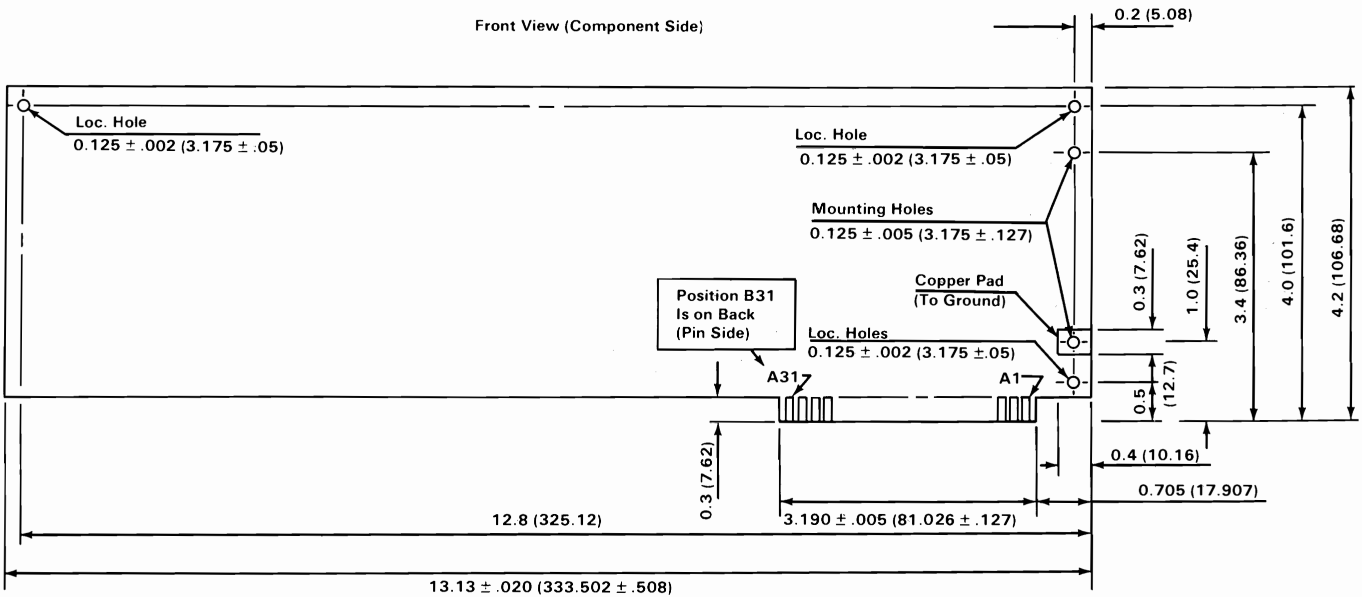
Specifications

The following voltages are available on the system-board I/O channel:

+ 5 Vdc ± 5% on 2 connector pins
– 5 Vdc ±10% on 1 connector pin
+12 Vdc ± 5% on 1 connector pin
–12 Vdc ±10% on 1 connector pin
GND (Ground) on 3 connector pins

Card Specifications

The specifications for option cards follow.

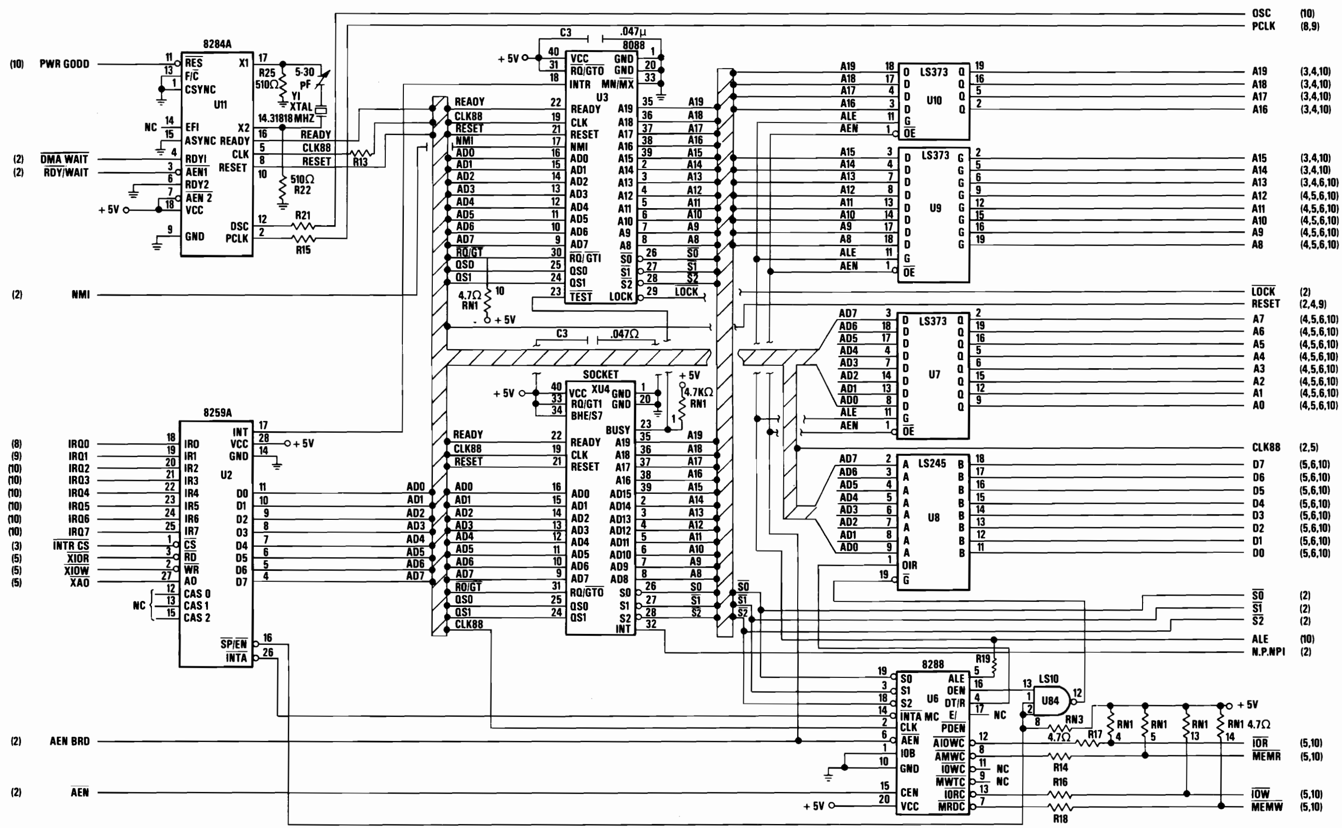


Notes:

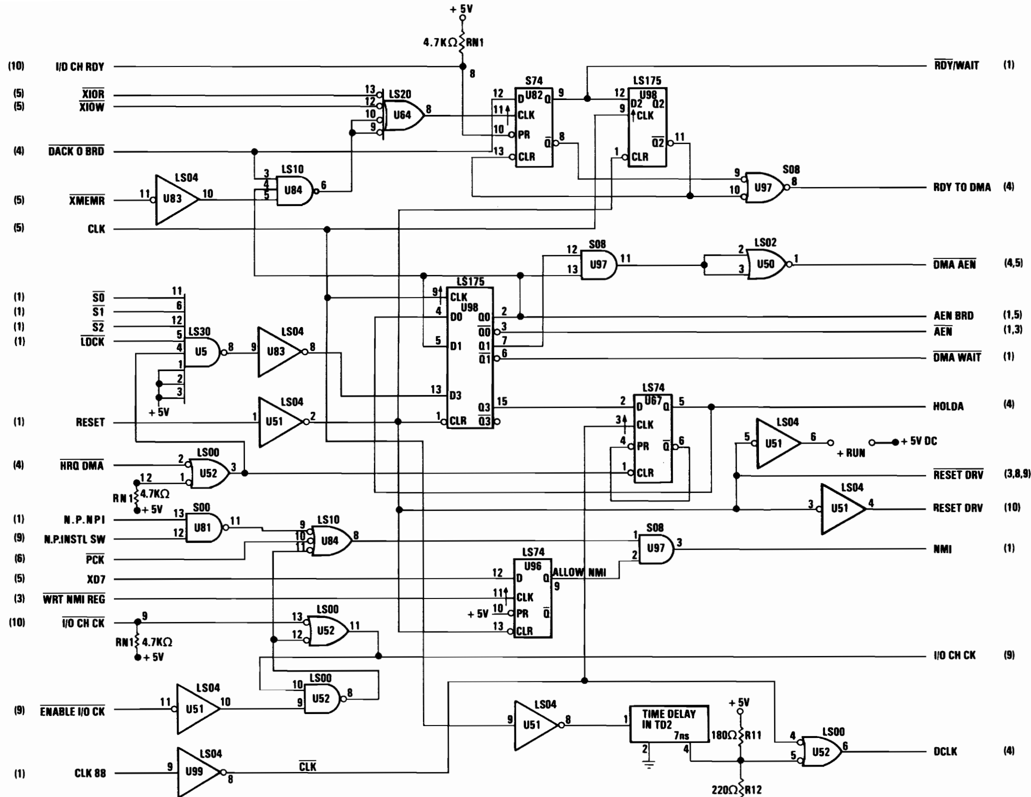
1. All Card Dimensions are ± .010 (.254) Tolerance (With Exceptions Indicated on Drawing or in Notes).
2. Max. Card Length is 13.15 (334.01) Smaller Length is Permissible.
3. Loc. and Mounting Holes are Non-Plated Thru. (Loc. 3X, Mtg. 2X).
4. 31 Gold Tabs Each Side, 0.100 ± .0005 (2.54 ± .0127) Center to Center, 0.06 ± .0005 (1.524 ± .0127) Width.
5. Numbers in Parentheses are in Millimeters. All Others are in Inches.

Logic Diagrams

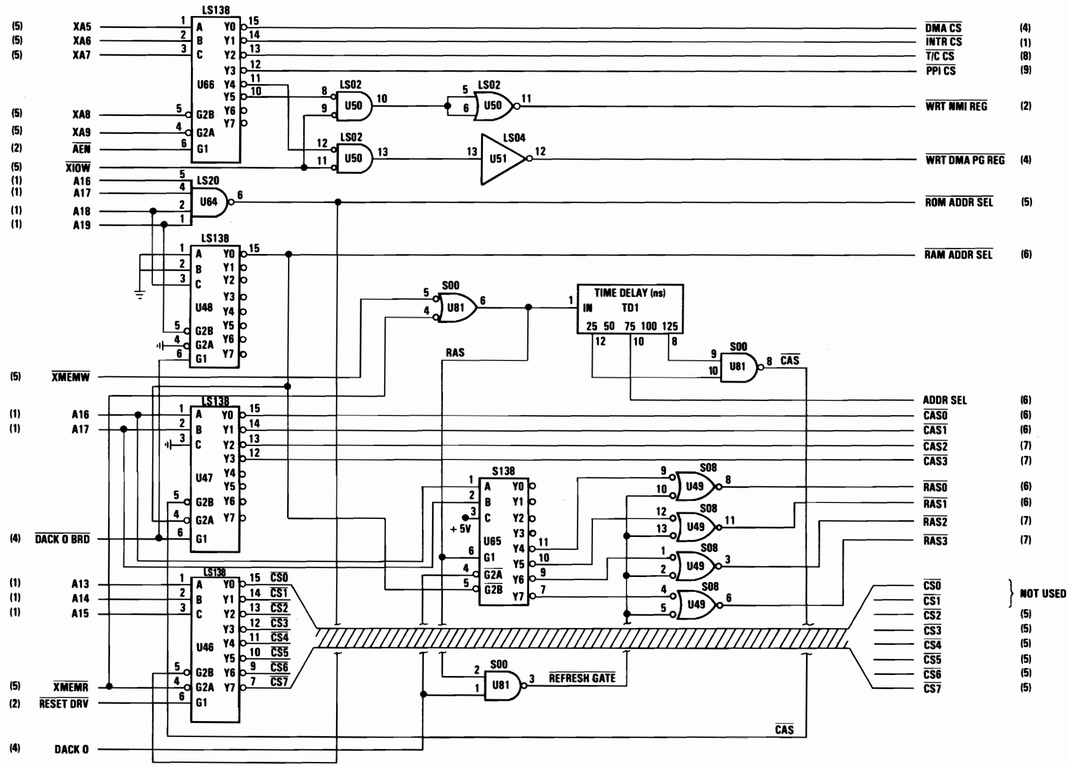
The following pages contain the logic diagrams for the system board.



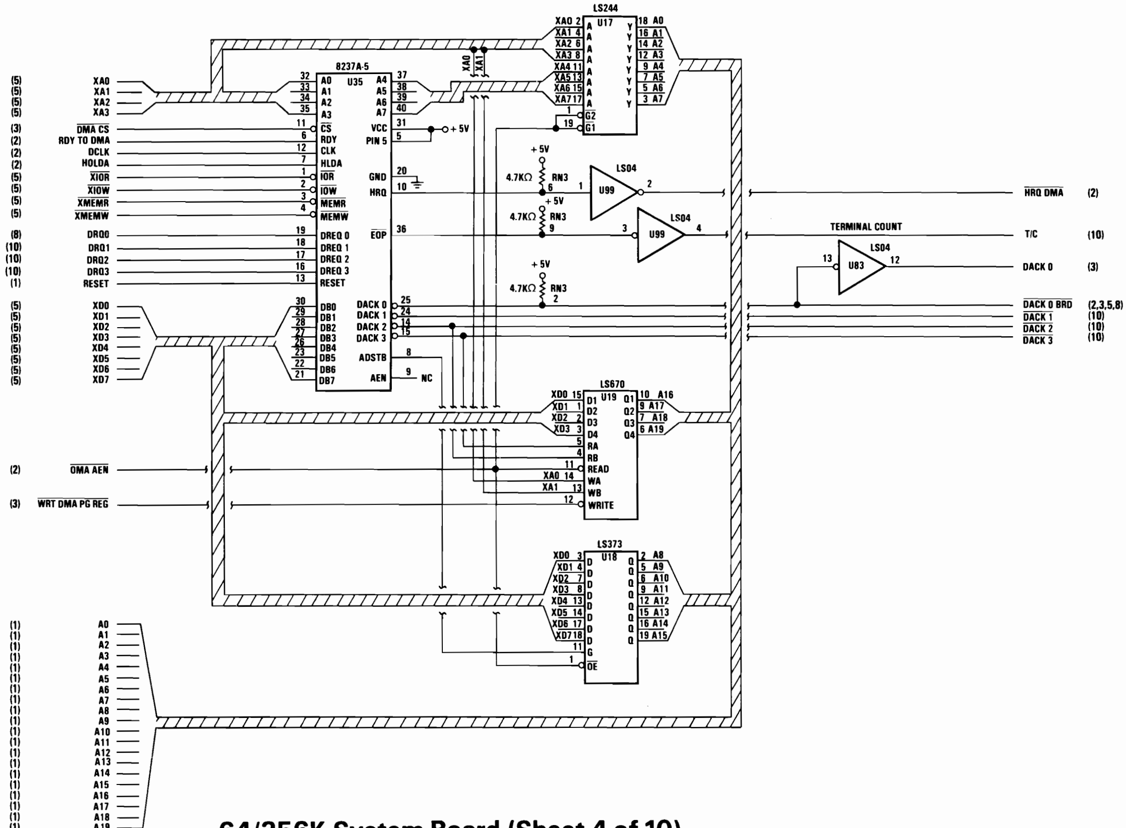
64/256K System Board (Sheet 1 of 10)



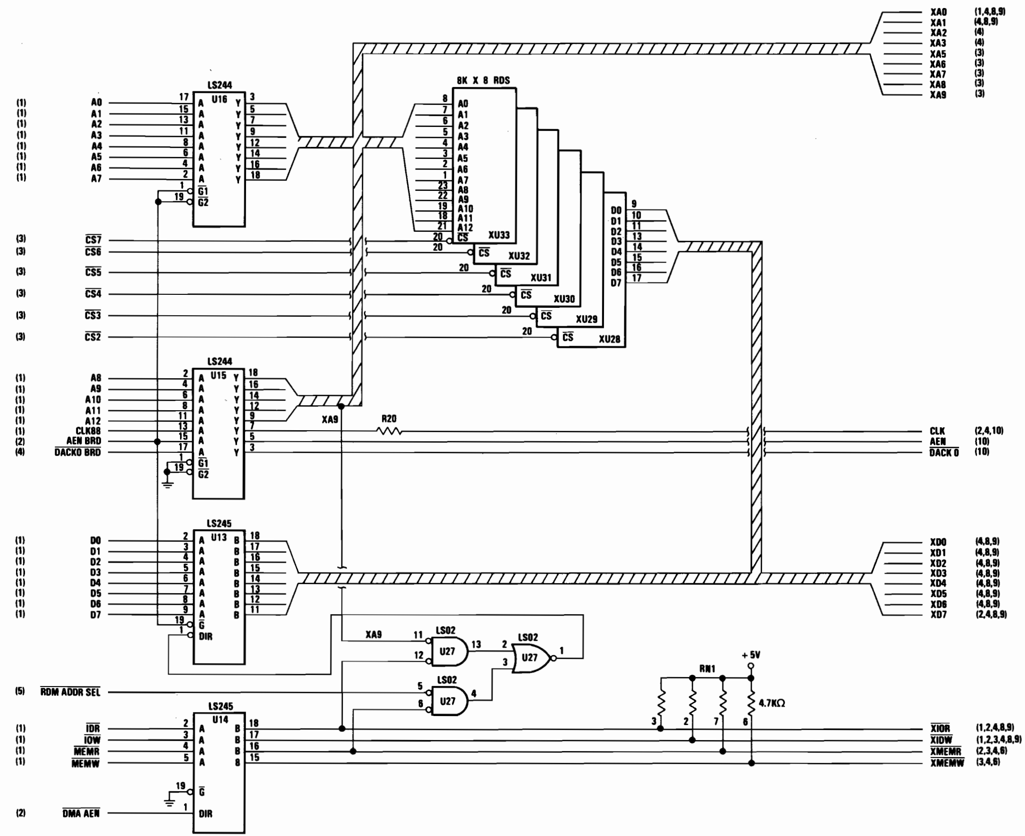
64/256K System Board (Sheet 2 of 10)



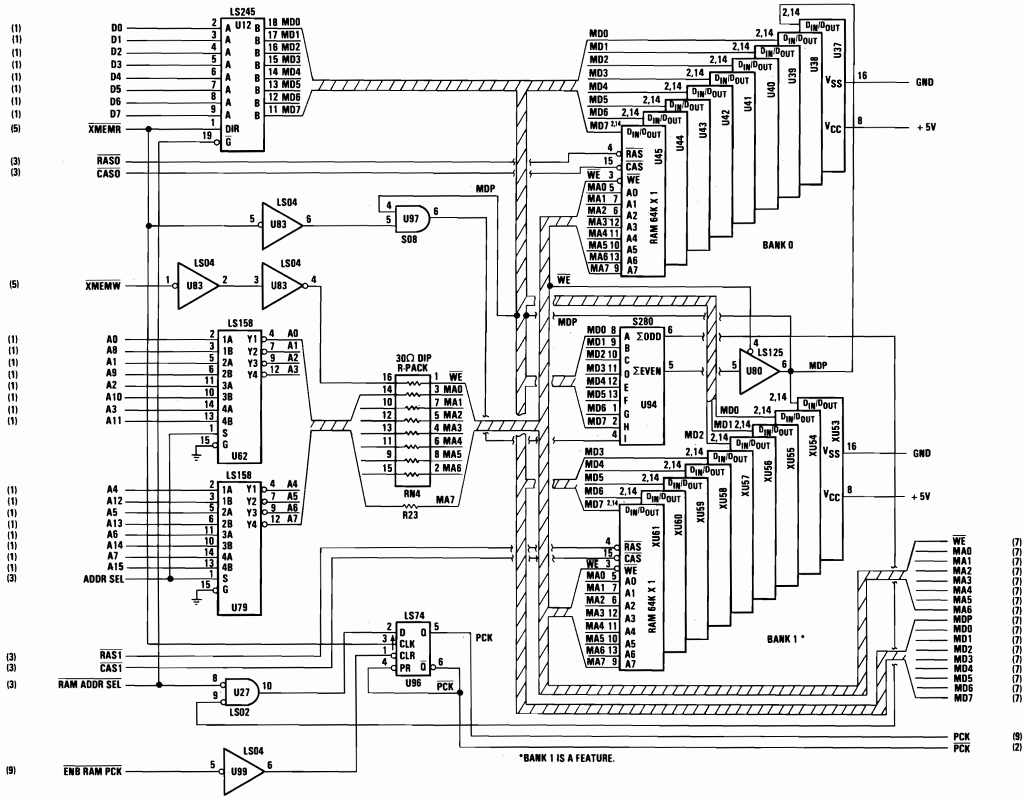
64/256K System Board (Sheet 3 of 10)



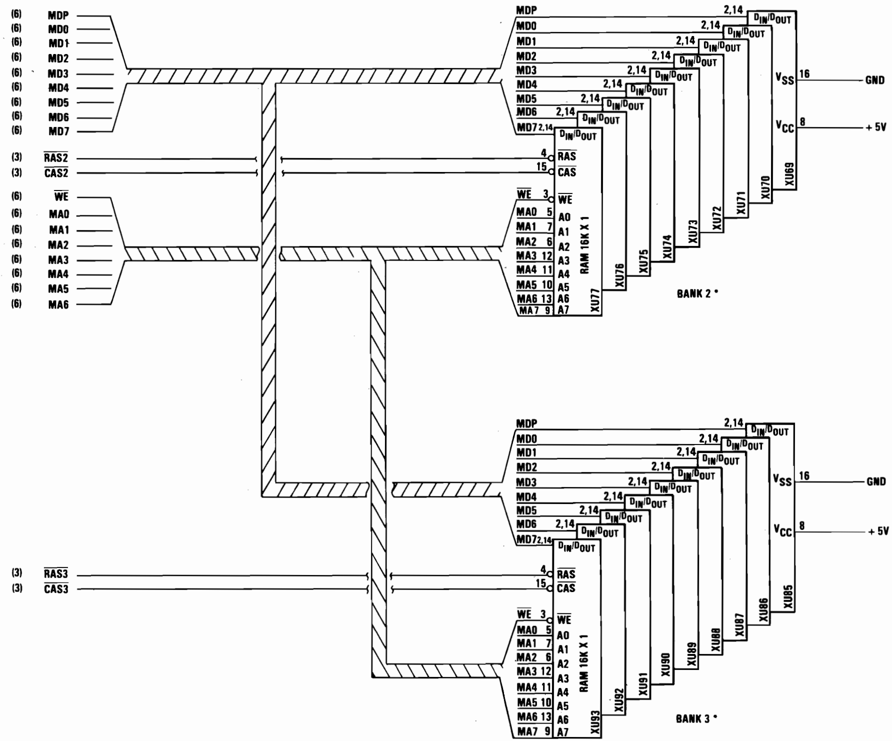
64/256K System Board (Sheet 4 of 10)



64/256K System Board (Sheet 5 of 10)

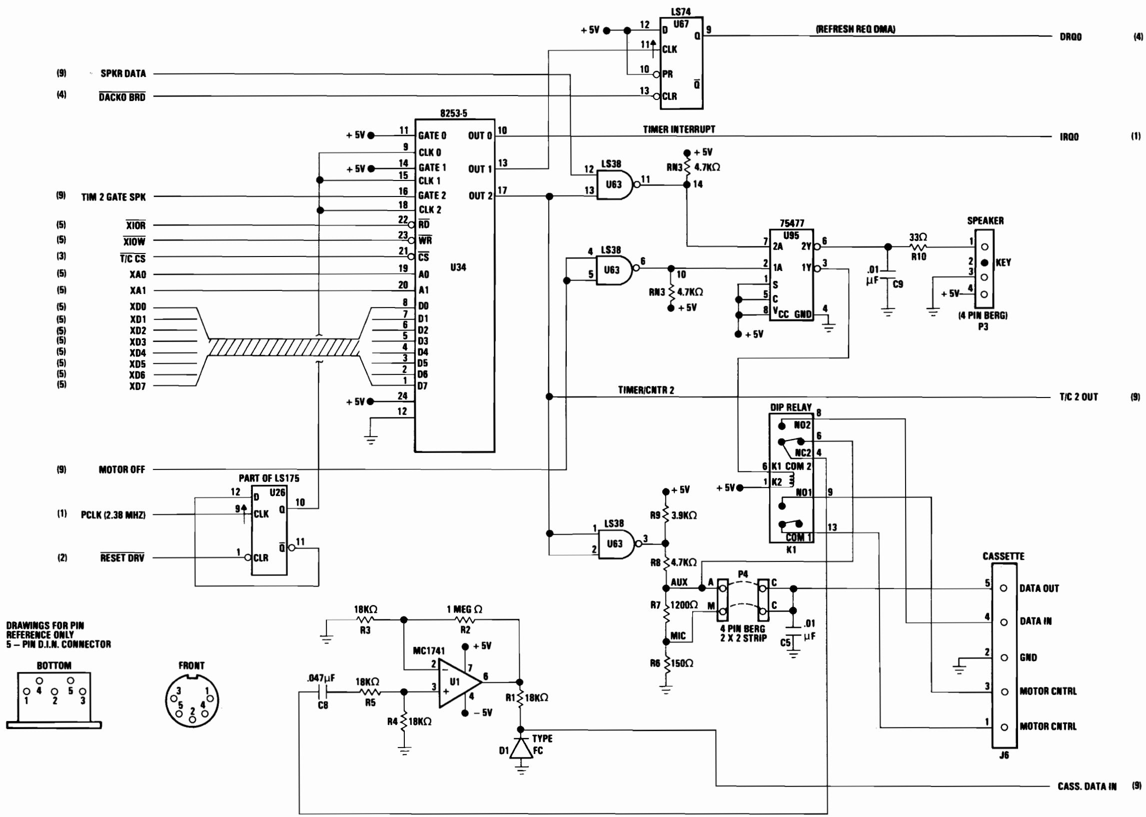


64/256K System Board (Sheet 6 of 10)

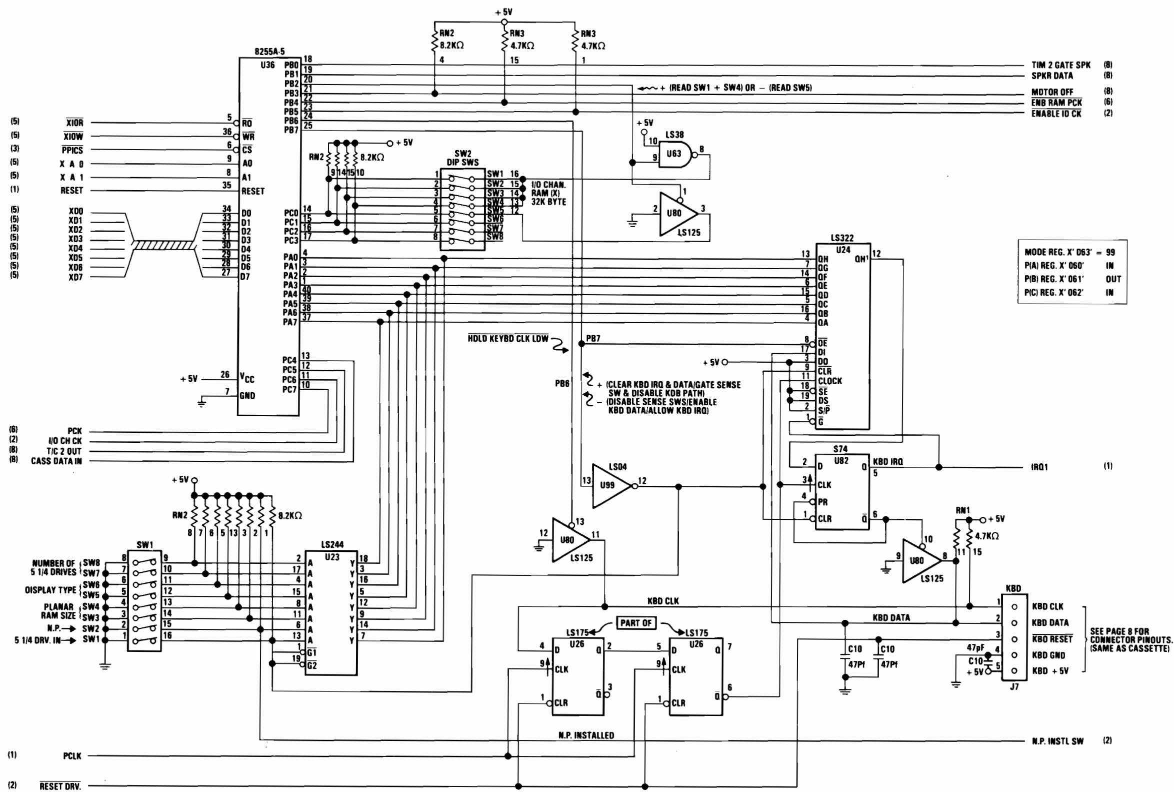


*BANKS 2 & 3 ARE FEATURES.

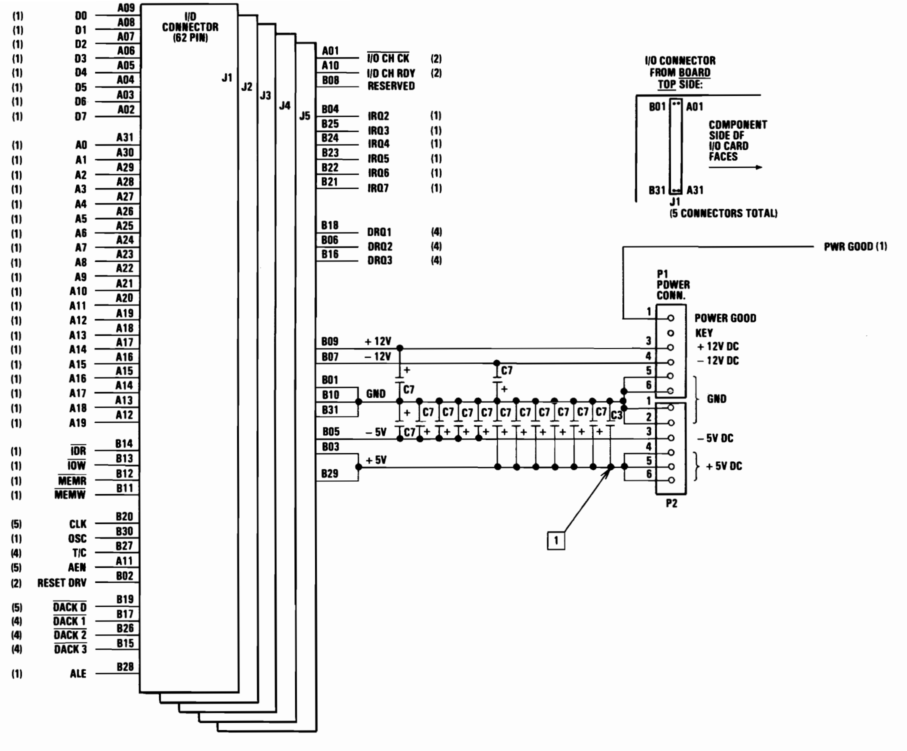
64/256K System Board (Sheet 7 of 10)



64/256K System Board (Sheet 8 of 10)



64/256K System Board (Sheet 9 of 10)



NOTE:

1 C3 QTY = 23 CAPS

64/256K System Board (10 of 10)

SECTION 2. COPROCESSOR

Contents

Description

The Math Coprocessor (8087) enables the IBM Personal Computer to perform high-speed arithmetic, logarithmic functions, and trigonometric operations with extreme accuracy.

The 8087 coprocessor works in parallel with the microprocessor. The parallel operation decreases operating time by allowing the coprocessor to do mathematical calculations while the microprocessor continues to do other functions.

The first five bits of every instruction's operation code for the coprocessor are identical (binary 11011). When the microprocessor and the coprocessor see this operation code, the microprocessor calculates the address of any variables in memory, while the coprocessor checks the instruction. The coprocessor takes the memory address from the microprocessor if necessary. To gain access to locations in memory, the coprocessor takes the local bus from the microprocessor when the microprocessor finishes its current instruction. When the coprocessor is finished with the memory transfer, it returns the local bus to the microprocessor.

The IBM Math Coprocessor works with seven numeric data types divided into the three classes listed below.

- Binary integers (3 types)
- Decimal integers (1 type)
- Real numbers (3 types)

Programming Interface

The coprocessor extends the data types, registers, and instructions to the microprocessor.

The coprocessor has eight 80-bit registers, which provide the equivalent capacity of the 40 16-bit registers found in the microprocessor. This register space allows constants and temporary results to be held in registers during calculations, thus reducing memory access and improving speed as well as bus availability. The register space can be used as a stack or as a fixed register set. When used as a stack, only the top two stack elements are operated on. The figure below shows representations of large and small numbers in each data type.

Data Type	Bits	Significant Digits (Decimal)	Approximate Range (decimal)
Word Integer	16	4	$-32{,}768 \le X \le +32{,}767$
Short Integer	32	9	$-2\text{x}10^{9} \le X \le +2\text{x}10^{9}$
Long Integer	64	18	$-9\text{x}10^{18} \le X \le +9\text{x}10^{18}$
Packed Decimal	80	18	$-99...99 \le X \le +99...99$ (18 digits)
Short Real*	32	6-7	$8.43\text{x}10^{-37} \le \lvert X \rvert \le 3.37\text{x}10^{38}$
Long Real*	64	15-16	$4.19\text{x}10^{-307} \le \lvert X \rvert \le 1.67\text{x}10^{308}$
Temporary Real	80	19	$3.4\text{x}10^{-4932} \le \lvert X \rvert \le 1.2\text{x}10^{4932}$

*The short and long real data types correspond to the single and double precision data types.

Data Types

Hardware Interface

The coprocessor uses the same clock generator and system bus interface components as the microprocessor. The coprocessor is wired directly into the microprocessor. The microprocessor's queue status lines (QS0 and QS1) enable the coprocessor to obtain and decode instructions simultaneously with the microprocessor. The coprocessor's 'busy' signal informs the microprocessor that it is executing; the microprocessor's WAIT instruction forces the microprocessor to wait until the coprocessor is finished executing (WAIT FOR NOT BUSY).

When an incorrect instruction is sent to the coprocessor (for example, divide by 0 or load a full register), the coprocessor can signal the microprocessor with an interrupt. There are three conditions that will disable the coprocessor interrupt to the microprocessor:

1. Exception and interrupt-enable bits of the control word are set to 1's.

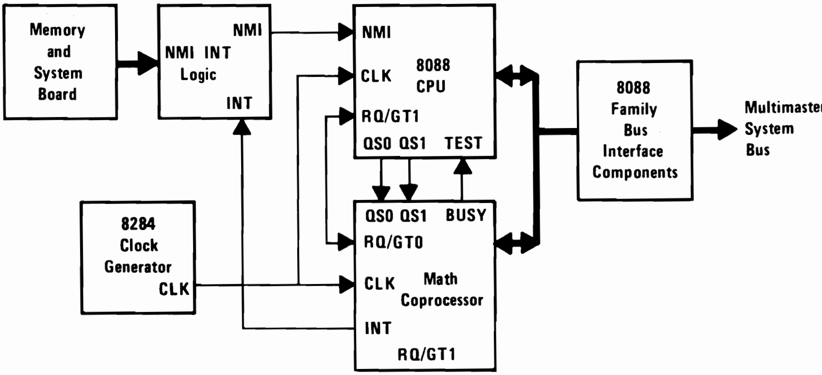
2. System-board switch-block 1, switch 2, set in the On position.

3. Non-maskable interrupt (NMI) register (REG) is set to zero.

At power-on time, the NMI REG is cleared to disable the NMI. Any program using the coprocessor's interrupt capability must ensure that conditions 2 and 3 are never met during the operation of the software or an "Endless WAIT" will occur. An "Endless WAIT" will have the microprocessor waiting for the 'not busy' signal from the coprocessor while the coprocessor is waiting for the microprocessor to interrupt.

Because a memory parity error may also cause an interrupt to the microprocessor NMI line, the program should check the coprocessor status for an exception condition. If a coprocessor exception condition is not found, control should be passed to the normal NMI handler. If an 8087 exception condition is found, the program may clear the exception by executing the FNSAVE or the FNCLEX instruction, and the exception can be identified and acted upon.

The NMI REG and the coprocessor's interrupt are tied to the NMI line through the NMI interrupt logic. Minor modifications to programs designed for use with a coprocessor must be made before the programs will be compatible with the IBM Personal Computer Math Coprocessor.



Coprocessor Interconnection

Detailed information for the internal functions of the Intel 8087 Coprocessor can be found in the books listed in the Bibliography.

SECTION 3. POWER SUPPLY

Contents

Description

The system power supply is located at the right rear of the system unit. It is an integral part of the system-unit chassis. Its housing provides support for the rear panel, and its fan furnishes cooling for the whole system.

It supplies the power and reset signal necessary for the operation of the system board, installed options, and the keyboard. It also provides a switched ac socket for the IBM Monochrome Display and two separate connectors for power to the 5-1/4 inch diskette drives.

The two different power supplies available are designed for continuous operation at 63.5 Watts. They have a fused 120 Vac or 220/240 Vac input and provide four regulated dc output voltages: 7 A at +5 Vdc, 2 A at +12 Vdc, 0.3 A at -5 Vdc, and 0.25 A at -12 Vdc. These outputs are overvoltage, overcurrent, open-circuit, and short-circuit protected. If a dc overload or overvoltage condition occurs, all dc outputs are shut down as long as the condition exists.

The +12 Vdc and -12 Vdc power the EIA drivers and receivers on the asynchronous communications adapter. The +12 Vdc also power's the system's dynamic memory and the two internal 5-1/4 inch diskette drive motors. It is assumed that only one drive is active at a time. The +5 Vdc powers the logic on the system board and diskette drives and allows about 4 A of +5 Vdc for the adapters in the system-unit expansion slots. The -5 Vdc is for dynamic memory bias voltage; it tracks the +5 Vdc and +12 Vdc very quickly at power-on and has a longer decay on power-off than the +5 Vdc and +12 Vdc outputs. All four power supply dc voltages are bussed across each of the five system-unit expansion slots.

Input Requirements

The following are the input requirements for the system unit power supply.

Voltage (Vac)			Frequency (Hz)	Current (Amps)
Nominal	Minimum	Maximum	+/– 3Hz	Maximum
120	104	127	60	2.5 at 104 Vac
220/240	180	259	50	1.0 at 180 Vac

Outputs

Vdc Output

The following are the dc outputs for the system unit power supply.

Voltage (Vdc)	Current (Amps)		Regulation (Tolerance)	
Nominal	Minimum	Maximum	+ %	– %
+ 5.0	2.3	7.0	5	4
– 5.0	0.0	0.3	10	8
+ 12.0	0.4	2.0	5	4
– 12.0	0.0	0.25	10	9

Vac Output

The power supply provides a filtered, fused, ac output that is switched on and off with the main power switch. The maximum current available at this output is 0.75 A. The receptacle provided at the rear of the power supply for this ac output is a nonstandard connector designed to be used only for the IBM Monochrome Display.

Overvoltage/Overcurrent Protection

The system power supply employs the protection features which are described below.

Primary (Input)

The following table describes the primary (input voltage) protection for the system-unit power supply.

Voltage (Nominal Vac)	Type Protection	Rating (Amps)
120	Fuse	2
220/240	Fuse	1

Secondary (Output)

On overvoltage, the power supply is designed to shut down all outputs when either the +5 Vdc or the +12 Vdc output exceeds 200% of its maximum rated voltage. On overcurrent, the supply will turn off if any output exceeds 130% of its nominal value.

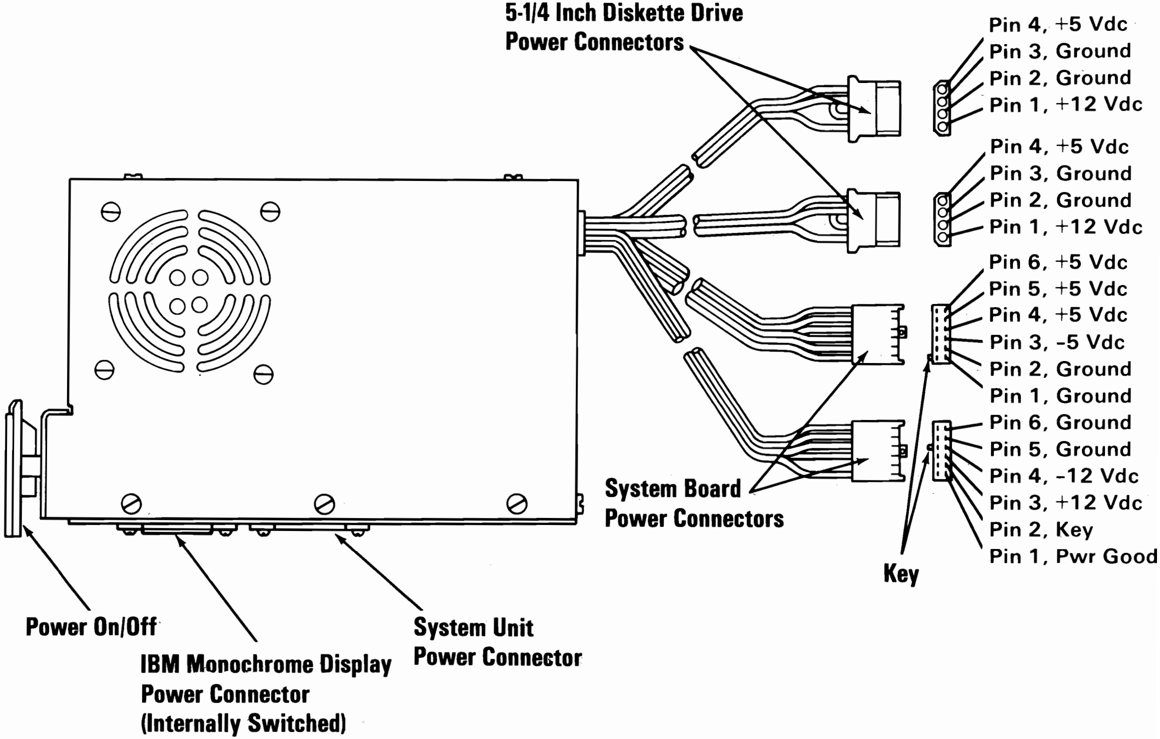
Power Good Signal

When the power supply is turned on after it has been off for a minimum of 5 seconds, it generates a 'power good' signal that indicates there is adequate power for processing. When the four output voltages are above the minimum sense levels, as described below, the signal sequences to a TTL-compatible up level (2.4 Vdc to 5.5 Vdc), is capable of sourcing 60 μA. When any of the four output voltages is below its minimum sense level or above its maximum sense level, the 'power good' signal will be TTL-compatible down level (0.0 Vdc to 0.4 Vdc) capable of supplying 500 μA. The 'power good' signal has a turn-on delay of 100-ms after the output voltages have reached their respective minimum sense levels.

Output Voltage	Under-Voltage Nominal Sense Level	Over-Voltage Nominal Sense Level
+ 5 Vdc	+ 4.0 Vdc	+ 5.9 Vdc
- 5 Vdc	- 4.0 Vdc	- 5.9 Vdc
+ 12 Vdc	+ 9.6 Vdc	+ 14.2 Vdc
- 12 Vdc	- 9.6 Vdc	- 14.2 Vdc

Power Supply Connectors and Pin Assignments

The power connector on the system board is a 12-pin male connector that plugs into the power-supply connectors. The pin configuration and locations follow.


5-1/4 Inch Diskette Drive Power Connectors
Pin 4, +5 Vdc
Pin 3, Ground
Pin 2, Ground
Pin 1, +12 Vdc
Pin 4, +5 Vdc
Pin 3, Ground
Pin 2, Ground
Pin 1, +12 Vdc
Pin 6, +5 Vdc
Pin 5, +5 Vdc
Pin 4, +5 Vdc
Pin 3, -5 Vdc
Pin 2, Ground
Pin 1, Ground
Pin 6, Ground
Pin 5, Ground
Pin 4, -12 Vdc
Pin 3, +12 Vdc
Pin 2, Key
Pin 1, Pwr Good
System Board Power Connectors
Key
Power On/Off
IBM Monochrome Display Power Connector (Internally Switched)
System Unit Power Connector

SECTION 4. KEYBOARD

Contents

Section 4

Description

The IBM Personal Computer keyboard has a permanently attached cable that connects to a DIN connector at the rear of the system unit. This shielded 5-wire cable has power (+5 Vdc), ground, two bidirectional signal lines, and one wire used as a 'reset' line. The cable is approximately 182.88 cm (6 ft) long and is coiled, like that of a telephone handset.

The keyboard uses a capacitive technology with a microprocessor (Intel 8048) performing the keyboard scan function. The keyboard has two tilt positions for operator comfort (5- or 15-degree tilt orientation).

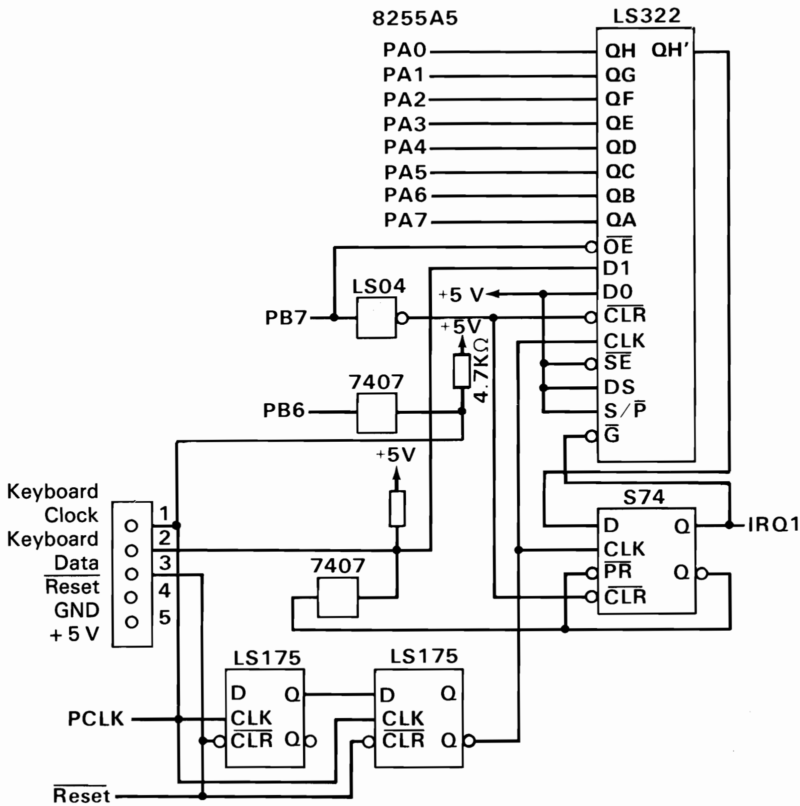
The keyboard has 83 keys arranged in three major groupings. The central portion of the keyboard is a standard typewriter keyboard layout. On the left side are 10 function keys. These keys are defined by the software. On the right is a 15-key keypad. These keys are also defined by the software, but have legends for the functions of numeric entry, cursor control, calculator pad, and screen edit.

The keyboard interface is defined so that system software has maximum flexibility in defining certain keyboard operations. This is accomplished by having the keyboard return scan codes rather than American Standard Code for Information Interchange (ASCII) codes. In addition, all keys are typematic (if held down, they will repeat) and generate both a make and a break scan code. For example, key 1 produces scan code hex 01 on make and code hex 81 on break. Break codes are formed by adding hex 80 to make codes. The keyboard I/O driver can define keyboard keys as shift keys or typematic, as required by the application.

The microprocessor (Intel 8048) in the keyboard performs several functions, including a power-on self test when requested by the system unit. This test checks the microprocessor (Intel 8048) ROM, tests memory, and checks for stuck keys. Additional functions are keyboard scanning, buffering of up to 16 key scan codes, maintaining bidirectional serial communications with the system unit, and executing the handshake protocol required by each scan-code transfer.

Several keyboard arrangements are available. These are illustrated on the following pages. For information about the keyboard routines required to implement non-U.S. keyboards, refer to the *Guide to Operations* and *DOS* manuals.

Block Diagram



Keyboard Interface Block Diagram

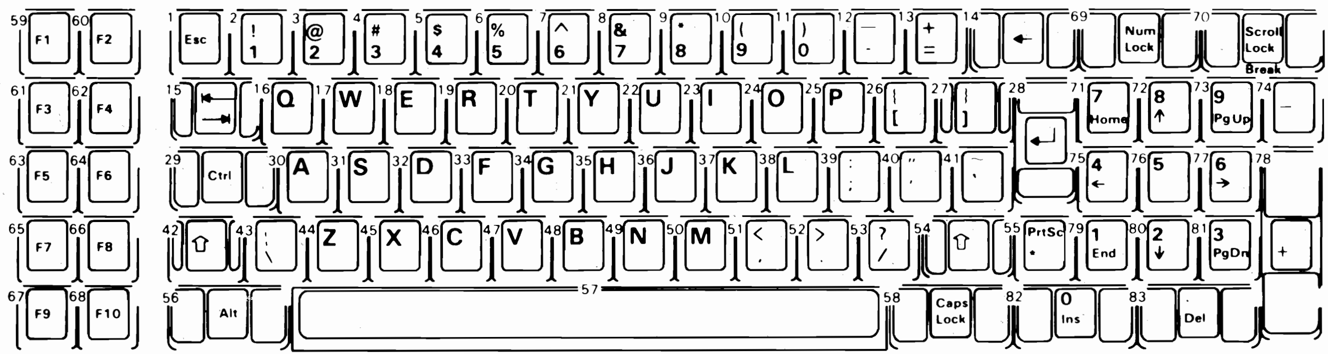
Keyboard Diagrams

The IBM Personal Computer keyboard is available in six layouts:

- U.S. English
- U.K. English
- French
- German
- Italian
- Spanish

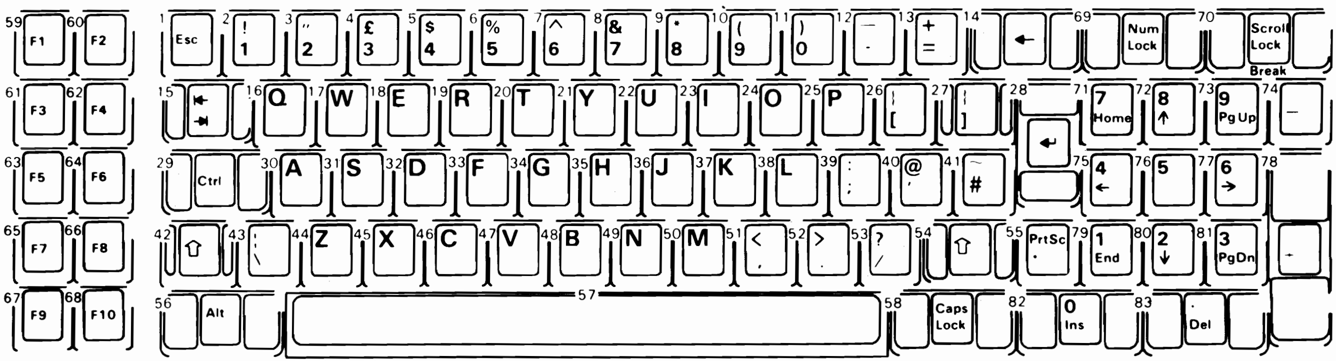
The following pages show all six keyboard layouts.

U.S. English Keyboard Diagram



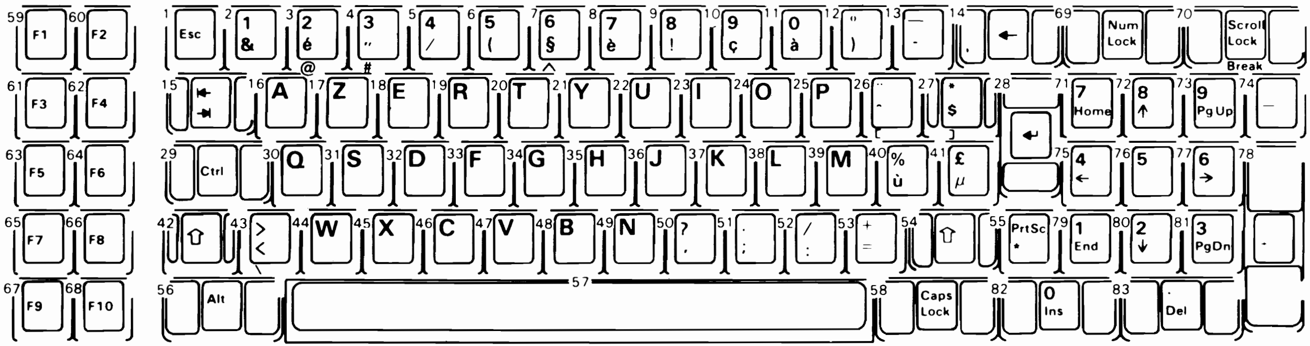
Note: Nomenclature is on both the top and front face of keybuttons as shown. The number to the upper left designates the button position.

U.K. English Keyboard Diagram



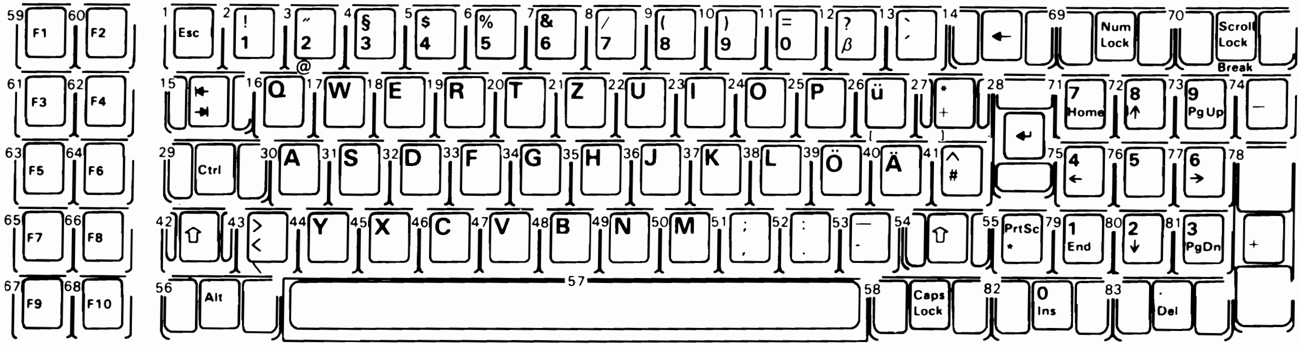
Note: Nomenclature is on both the top and front face of keybuttons as shown. The number to the upper left designates the button position.

French Keyboard Diagram



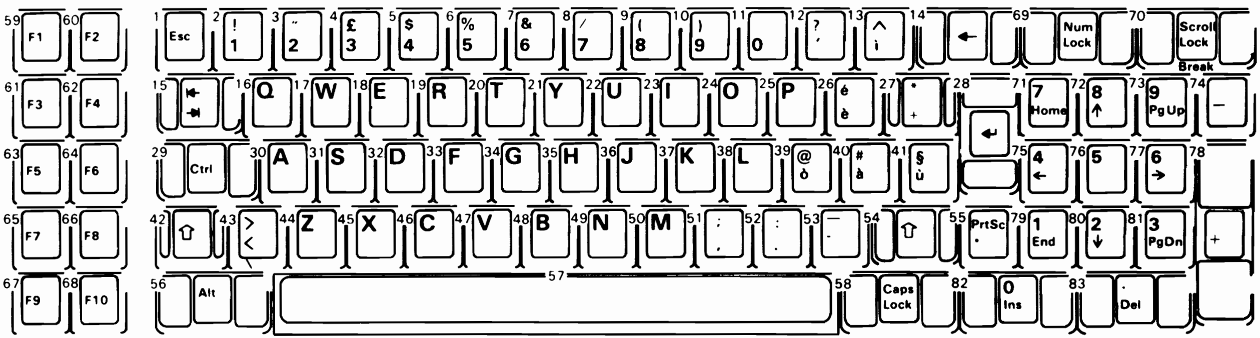
Note: Nomenclature is on both the top and front face of keybuttons as shown. The number to the upper left designates the button position.

German Keyboard Diagram

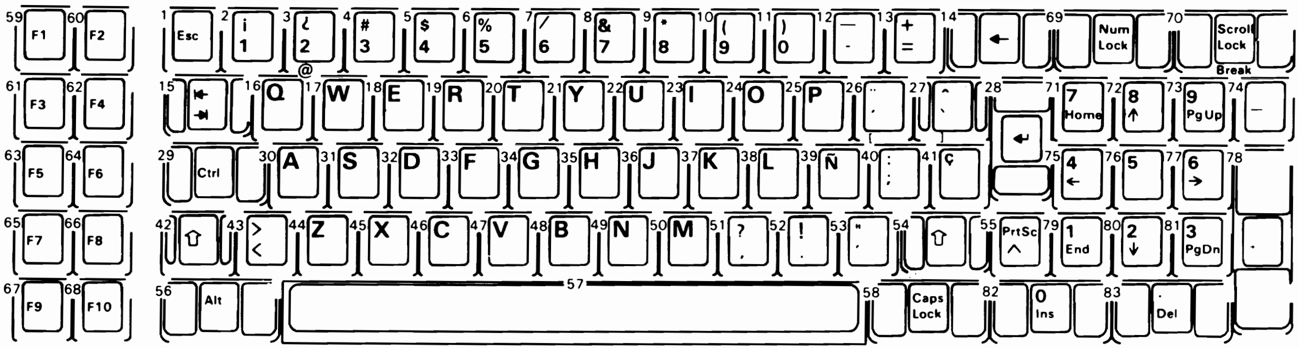


Note: Nomenclature is on both the top and front face of keybuttons as shown. The number to the upper left designates the button position.

Italian Keyboard Diagram

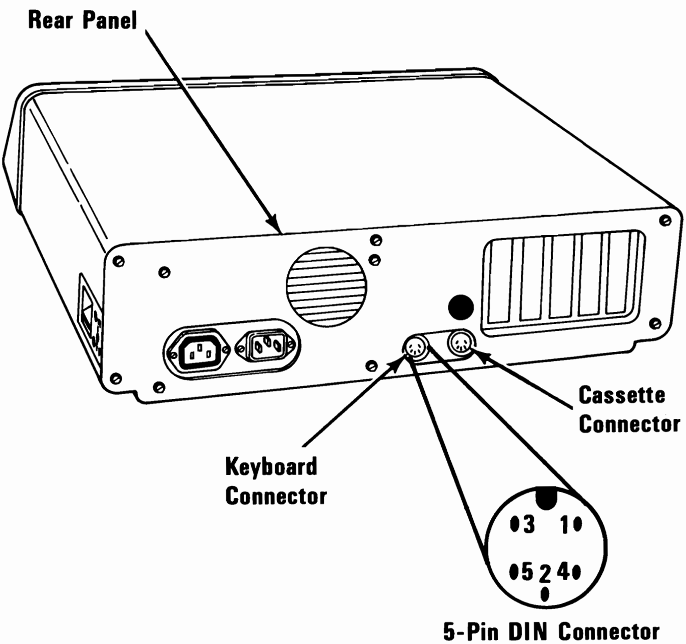


Note: Nomenclature is on both the top and front face of keybuttons as shown. The number to the upper left designates the button position.



Note: Nomenclature is on both the top and front face of keybuttons as shown. The number to the upper left designates the button position.

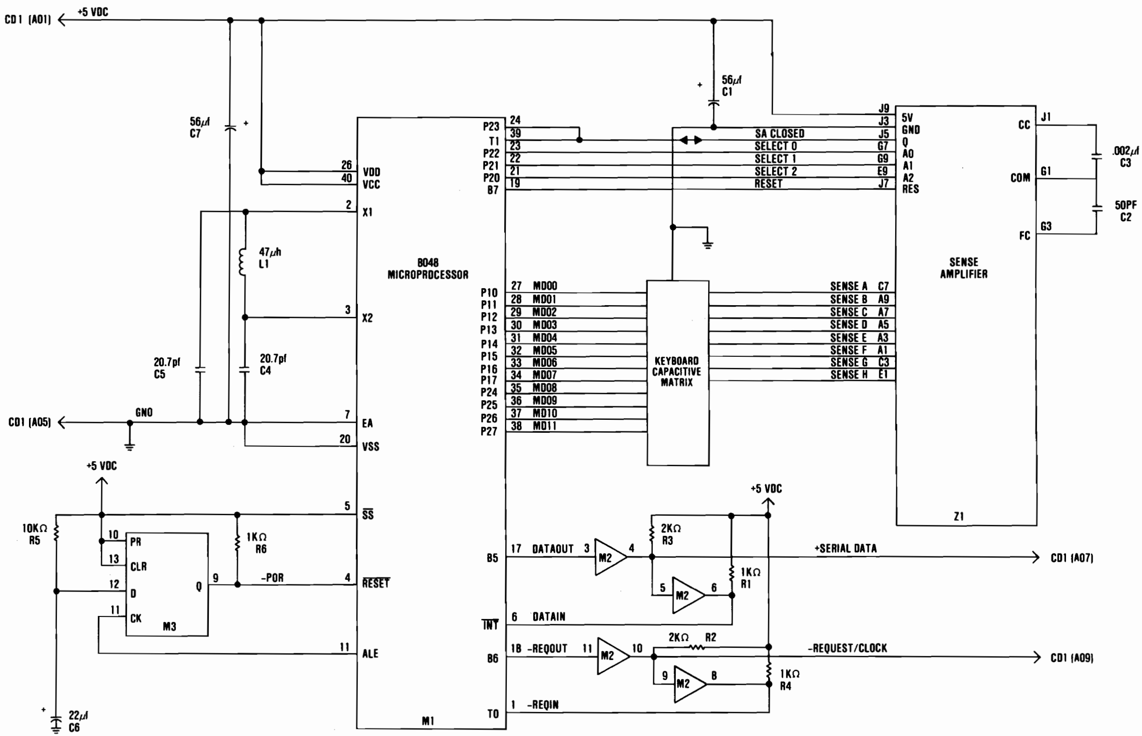
Connector Specifications



Pin	TTL Signal	Signal Level
1	+ Keyboard Clock	+ 5 Vdc
2	+ Keyboard Data	+ 5 Vdc
3	– Keyboard Reset (Not used by keyboard)	
	Power Supply Voltages	**Voltage**
4	Ground	0
5	+ 5 Volts	+ 5 Vdc

Keyboard Interface Connector Specifications

Keyboard Logic Diagram



IBM Keyboard (Sheet 1 of 1)

SECTION 5. SYSTEM BIOS

Contents

System BIOS Usage

The basic input/output system (BIOS) resides in ROM on the system board and provides device level control for the major I/O devices in the system. Additional ROM modules may be located on option adapters to provide device level control for that option adapter. BIOS routines enable the assembler language programmer to perform block (disk and diskette) or character-level I/O operations without concern for device address and operating characteristics. System services, such as time-of-day and memory size determination, are provided by the BIOS.

The goal is to provide an operational interface to the system and relieve the programmer of the concern about the characteristics of hardware devices. The BIOS interface insulates the user from the hardware, thus allowing new devices to be added to the system, yet retaining the BIOS level interface to the device. In this manner, user programs become transparent to hardware modifications and enhancements.

The IBM Personal Computer *MACRO Assembler* manual and the IBM Personal Computer *Disk Operating System (DOS)* manual provide useful programming information related to this section. A complete listing of the BIOS is given in this section.

Access to the BIOS is through the 8088 software interrupts. Each BIOS entry point is available through its own interrupt.

The software interrupts, hex 10 through hex 1A, each access a different BIOS routine. For example, to determine the amount of memory available in the system,

INT 12H

invokes the BIOS routine for determining memory size and returns the value to the caller.

Parameter Passing

All parameters passed to and from the BIOS routines go through the 8088 registers. The prologue of each BIOS function indicates the registers used on the call and the return. For the memory size example, no parameters are passed. The memory size, in 1K-byte increments, is returned in the AX register.

If a BIOS function has several possible operations, the AH register is used at input to indicate the desired operation. For example, to set the time of day, the following code is required:

```
MOV  AH,1               ;function is to set time of day.
MOV  CX,HIGH_COUNT      ;establish the current time.
MOV  DX,LOW_COUNT
INT  1AH                ;set the time.
```

To read the time of day:

```
MOV  AH,0               ;function is to read time of day.
INT  1AH                ;read the timer.
```

Generally, the BIOS routines save all registers except for AX and the flags. Other registers are modified on return only if they are returning a value to the caller. The exact register usage is in the prologue of each BIOS function.

Address (Hex)	Interrupt Number	Name	BIOS Entry
0-3	0	Divide by Zero	D_EOI
4-7	1	Single Step	D_EOI
8-B	2	Nonmaskable	NMI_INT
C-F	3	Breakpoint	D_EOI
10-13	4	Overflow	D_EOI
14-17	5	Print Screen	PRINT_SCREEN
18-1B	6	Reserved	D_EOI
1D-1F	7	Reserved	D_EOI
20-23	8	Time of Day	TIMER_INT
24-27	9	Keyboard	KB_INT
28-2B	A	Reserved	D_EOI
2C-2F	B	Communications	D_EOI
30-33	C	Communications	D_EOI
34-37	D	Disk	D_EOI
38-3B	E	Diskette	DISK_INT
3C-3F	F	Printer	D_EOI
40-43	10	Video	VIDEO_IO
44-47	11	Equipment Check	EQUIPMENT
48-4B	12	Memory	MEMORY_SIZE _DETERMINE
4C-4F	13	Diskette/Disk	DISKETTE_IO
50-53	14	Communications	RS232_IO
54-57	15	Cassette	CASSETTE_IO
58-5B	16	Keyboard	KEYBOARD_IO
5C-5F	17	Printer	PRINTER_IO
60-63	18	Resident BASIC	F600:0000
64-67	19	Bootstrap	BOOT_STRAP
68-6B	1A	Time of Day	TIME_OF_DAY
6C-6F	1B	Keyboard Break	DUMMY_RETURN
70-73	1C	Timer Tick	DUMMY_RETURN
74-77	1D	Video Initialization	VIDEO_PARMS
78-7B	1E	Diskette Parameters	DISK_BASE
7C-7F	1F	Video Graphics Characters	0
100-103	40	Diskette pointer save area for Fixed Disk	
104-107	41	Fixed Disk Parameters	FD_TBL
168-16B	5A	Cluster	D000:XXXX
16C-16F	5B	Used by Cluster Program	N/A
180-19F	60-67	Reserved for User Programs	N/A

8088 Software Interrupt Listing

Vectors with Special Meanings

Interrupt Hex 1B - Keyboard Break Address

This vector points to the code to be used when the Ctrl and Break keys are pressed on the keyboard. The vector is invoked while responding to the keyboard interrupt, and control should be returned through an IRET instruction. The power-on routines initialize this vector to an IRET instruction, so that nothing will occur when the Ctrl and Break keys are pressed unless the application program sets a different value.

Control may be retained by this routine, with the following problems. The Break may have occurred during interrupt processing, so that one or more End of Interrupt commands must be sent to the 8259 Controller. Also, all I/O devices should be reset in case an operation was underway at that time.

Interrupt Hex 1C - Timer Tick

This vector points to the code to be executed on every system-clock tick. This vector is invoked while responding to the timer interrupt, and control should be returned through an IRET instruction. The power-on routines initialize this vector to point to an IRET instruction, so that nothing will occur unless the application modifies the pointer. It is the responsibility of the application to save and restore all registers that will be modified.

Interrupt Hex 1D - Video Parameters

This vector points to a data region containing the parameters required for the initialization of the 6845 on the video card. Note that there are four separate tables, and all four must be reproduced if all modes of operation are to be supported. The power-on routines initialize this vector to point to the parameters contained in the ROM video routines.

Interrupt Hex 1E - Diskette Parameters

This vector points to a data region containing the parameters required for the diskette drive. The power-on routines initialize the vector to point to the parameters contained in the ROM diskette routine. These default parameters represent the specified values for any IBM drives attached to the system. Changing this parameter block may be necessary to reflect the specifications of the other drives attached.

Interrupt Hex 1F - Graphics Character Extensions

When operating in the graphics modes of the IBM Color/Graphics Monitor Adapter (320 by 200 or 640 by 200), the read/write character interface forms the character from the ASCII code point, using a set of dot patterns. The dot patterns for the first 128 code points are contained in ROM. To access the second 128 code points, this vector must be established to point at a table of up to 1K bytes, where each code point is represented by eight bytes of graphic information. At power-on, this vector is initialized to 000:0, and it is the responsibility of the user to change this vector if additional code points are required.

Interrupt Hex 40 - Reserved

When an IBM Fixed Disk Adapter is installed, the BIOS routines use interrupt hex 30 to revector the diskette pointer.

Interrupt Hex 41 - Fixed Disk Parameters

This vector points to a data region containing the parameters required for the fixed disk drive. The power-on routines initialize the vector to point to the parameters contained in the ROM disk routine. These default parameters represent the specified values for any IBM fixed disk drives attached to the system. Changing this parameter block may be necessary to reflect the specifications of the other fixed disk drives attached.

Other Read/Write Memory Usage

The IBM BIOS routines use 256 bytes of memory from absolute hex 400 to hex 4FF. Locations hex 400 to 407 contain the base addresses of any RS-232C cards attached to the system. Locations hex 408 to 40F contain the base addresses of the Printer Adapter.

Memory locations hex 300 to 3FF are used as a stack area during the power-on initialization, and bootstrap when control is passed to it from power-on. If the user desires the stack in a different area, the area must be set by the application.

Address (Hex)	Interrupt (Hex)	Function
80-83	20	DOS Program Terminate
84-87	21	DOS Function Call
88-8B	22	DOS Terminate Address
8C-8F	23	DOS Ctrl Break Exit Address
90-93	24	DOS Fatal Error Vector
94-97	25	DOS Absolute Disk Read
98-9B	26	DOS Absolute Disk Write
9C-9F	27	DOS Terminate, Fix In Storage
A0-FF	28-3F	Reserved for DOS
100-17F	40-5F	Reserved
180-19F	60-67	Reserved for User Software Interrupts
1A0-1FF	68-7F	Not Used
200-217	80-85	Reserved by BASIC
218-3C3	86-F0	Used by BASIC Interpreter while BASIC is running
3C4-3FF	F1-FF	Not Used

BASIC and DOS Reserved Interrupts

Address (Hex)	Mode	Function
400-48F	ROM BIOS	See BIOS Listing
490-4EF		Reserved
4F0-4FF		Reserved as Intra-Application Communication Area for any application
500-5FF		Reserved for DOS and BASIC
500	DOS	Print Screen Status Flag Store 0-Print Screen Operation Not Active or Successful Print Screen Operation 1-Print Screen In Progress 255-Error Encountered during Print Screen Operation
504	DOS	Single Drive Mode Status Byte
510-511	BASIC	BASIC's Segment Address Store
512-515	BASIC	Clock Interrupt Vector Segment: Offset Store
516-519	BASIC	Break Key Interrupt Vector Segment: Offset Store
51A-51D	BASIC	Disk Error Interrupt Vector Segment: Offset Store

Reserved Memory Locations

If you do DEF SEG (default workspace segment):

	Offset (Hex Value)	Length
Line number of current line being executed	2E	2
Line number of last error	347	2
Offset into segment of start of program text	30	2
Offset into segment of start of variables (end of program text 1-1)	358	2
Keyboard buffer contents if 0-no characters in buffer if 1-characters in buffer	6A	1
Character color in graphics mode Set to 1, 2, or 3 to get text in colors 1 to 3. Do not set to 0. (Default = 3)	4E	1

Example

```
100 Print   PEEK (&H2E) + 256*PEEK (&H2F)
                  L              H
  100       | Hex 64 | Hex 00 |
```

BASIC Workspace Variables

Section 5

Starting Address in Hex	
00000	BIOS Interrupt Vectors
00080	Available Interrupt Vectors
00400	BIOS Data Area
00500	User Read/Write Memory
C8000	Disk Adapter
F0000	Read Only Memory
FE000	Bios Program Area

BIOS Memory Map

BIOS Programming Hints

The BIOS code is invoked through software interrupts. The programmer should not "hard code" BIOS addresses into application programs. The internal workings and absolute addresses within BIOS are subject to change without notice.

If an error is reported by the disk or diskette code, you should reset the drive adapter and retry the operation. A specified number of retries should be required on diskette reads to ensure the problem is not due to motor start-up.

When altering I/O-port bit values, the programmer should change only those bits that are necessary to the current task. Upon completion, the programmer should restore the original environment. Failure to adhere to this practice may be incompatible with present and future applications.

Adapter Cards with System-Accessible ROM Modules

The ROM BIOS provides a facility to integrate adapter cards with on-board ROM code into the system. During the POST, interrupt vectors are established for the BIOS calls. After the default vectors are in place, a scan for additional ROM modules takes place. At this point, a ROM routine on the adapter card may gain control. The routine may establish or intercept interrupt vectors to hook themselves into the system.

The absolute addresses hex C8000 through hex F4000 are scanned in 2K blocks in search of a valid adapter card ROM. A valid ROM is defined as follows:

Byte 0: Hex 55
Byte 1: Hex AA
Byte 2: A length indicator representing the number of 512-byte blocks in the ROM (length/512). A checksum is also done to test the integrity of the ROM module. Each byte in the defined ROM is summed modulo hex 100. This sum must be 0 for the module to be deemed valid.

Section 5

When the POST identifies a valid ROM, it does a far call to byte 3 of the ROM (which should be executable code). The adapter card may now perform its power-on initialization tasks. The feature ROM should return control to the BIOS routines by executing a far return.

Keyboard Encoding and Usage

Encoding

The keyboard routine provided by IBM in the ROM BIOS is responsible for converting the keyboard scan codes into what will be termed "Extended ASCII."

Extended ASCII encompasses one-byte character codes with possible values of 0 to 255, an extended code for certain extended keyboard functions, and functions handled within the keyboard routine or through interrupts.

Character Codes

The following character codes are passed through the BIOS keyboard routine to the system or application program. A '-1' means the combination is suppressed in the keyboard routine. The codes are returned in AL.

Key Number	Base Case	Upper Case	Ctrl	Alt
1	Esc	Esc	Esc	– 1
2	1	!	– 1	Note 1
3	2	@	Nul (000) Note 1	Note 1
4	3	#	– 1	Note 1
5	4	$	– 1	Note 1
6	5	%	– 1	Note 1
7	6	^	RS(030)	Note 1
8	7	&	– 1	Note 1
9	8	*	– 1	Note 1
10	9	(	– 1	Note 1
11	0	)	– 1	Note 1
12	-	—	US(031)	Note 1
13	=	+	– 1	Note 1
14	Backspace (008)	Backspace (008)	Del (127)	– 1
15	⟶| (009)	|⟵ (Note 1)	– 1	– 1
16	q	Q	DC1 (017)	Note 1
17	w	W	ETB (023)	Note 1

Character Codes (Part 1 of 3)

Section 5

Key Number	Base Case	Upper Case	Ctrl	Alt
18	e	E	ENQ (005)	Note 1
19	r	R	DC2 (018)	Note 1
20	t	T	DC4 (020)	Note 1
21	y	Y	EM (025)	Note 1
22	u	U	NAK (021)	Note 1
23	i	I	HT (009)	Note 1
24	o	O	SI (015)	Note 1
25	p	P	DLE (016)	Note 1
26	[	{	Esc (027)	−1
27	]	}	GS (029)	−1
28	CR	CR	LF (010)	−1
29 Ctrl	−1	−1	−1	−1
30	a	A	SOH (001)	Note 1
31	s	S	DC3 (019)	Note 1
32	d	D	EOT (004)	Note 1
33	f	F	ACK (006)	Note 1
34	g	G	BEL (007)	Note 1
35	h	H	BS (008)	Note 1
36	j	J	LF (010)	Note 1
37	k	K	VT (011)	Note 1
38	l	L	FF (012)	Note 1
39	;	:	−1	−1
40	'	"	−1	−1
41	`	~	−1	−1
42 Shift	−1	−1	−1	−1
43	\	¦	FS (028)	−1
44	z	Z	SUB (026)	Note 1
45	x	X	CAN (024)	Note 1
46	c	C	ETX (003)	Note 1
47	v	V	SYN (022)	Note 1
48	b	B	STX (002)	Note 1
49	n	N	SO (014)	Note 1
50	m	M	CR (013)	Note 1
51	,	<	−1	−1
52	.	>	−1	−1
53	/	?	−1	−1
54 Shift	−1	−1	−1	−1
55	*	(Note 2)	(Note 1)	−1
56 Alt	−1	−1	−1	−1
57	SP	SP	SP	SP
58 Caps Lock	−1	−1	−1	−1
59	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)
60	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)
61	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)
62	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)
63	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)
64	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)

Character Codes (Part 2 of 3)

Key Number	Base Case	Upper Case	Ctrl	Alt
65	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)
66	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)
67	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)
68	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)	Nul (Note 1)
69 Num Lock	– 1	– 1	Pause (Note 2)	– 1
70 Scroll Lock	– 1	– 1	Break (Note 2)	– 1
Notes: 1. Refer to ''Extended Codes'' in this section. 2. Refer to ''Special Handling'' in this section.				

Character Codes (Part 3 of 3)

Keys 71 through 83 have meaning only in base case, in Num Lock (or shifted) states, or in Ctrl state. Note that the Shift key temporarily reverses the current Num Lock state.

Key Number	Num Lock	Base Case	Alt	Ctrl
71	7	Home (Note 1)	– 1	Clear Screen
72	8	↑ (Note 1)	– 1	– 1
73	9	Page Up (Note 1)	– 1	Top of Text and Home
74	-	------------------------	– 1	– 1
75	4	← (Note 1)	– 1	Reverse Word (Note 1)
76	5	– 1	– 1	– 1
77	6	→ (Note 1)	– 1	Advance Word (Note 1)
78	+	+	– 1	– 1
79	1	End (Note 1)	– 1	Erase to EOL (Note 1)
80	2	↓ (Note 1)	– 1	– 1
81	3	Page Down (Note 1)	– 1	Erase to EOS (Note 1)
82	0	Ins	– 1	– 1
83		Del (Notes 1,2)	Note 2	Note 2
Notes: 1. Refer to ''Extended Codes'' in this section. 2. Refer to ''Special Handling'' in this section.				

Extended Codes

Extended Functions

For certain functions that cannot be represented in the standard ASCII code, an extended code is used. A character code of 000 (Nul) is returned in AL. This indicates that the system or application program should examine a second code that will indicate the actual function. Usually, but not always, this second code is the scan code of the primary key that was pressed. This code is returned in AH.

Second Code	Function
3	Nul Character
15	←
16-25	Alt Q, W, E, R, T, Y, U, I, O, P
30-38	Alt A, S, D, F, G, H, J, K, L
44-50	Alt Z, X, C, V, B, N, M
59-68	F1 to F10 Function Keys Base Case
71	Home
72	↑
73	Page Up and Home Cursor
75	←
77	→
79	End
80	↓
81	Page Down and Home Cursor
82	Ins (Insert)
83	Del (Delete)
84-93	F11 to F20 (Uppercase F1 to F10)
94-103	F21 to F30 (Ctrl F1 to F10)
104-113	F31 to F40 (Alt F1 to F10)
114	Ctrl PrtSc (Start/Stop Echo to Printer)
115	Ctrl ← (Reverse Word)
116	Ctrl → (Advance Word)
117	Ctrl End [Erase to End of Line (EOL)]
118	Ctrl PgDn [Erase to End of Screen (EOS)]
119	Ctrl Home (Clear Screen and Home)
120-131	Alt 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, -, = (Keys 2-13)
132	Ctrl PgUp (Top 25 Lines of Text and Home Cursor)

Keyboard Extended Functions

Shift States

Most shift states are handled within the keyboard routine, transparent to the system or application program. In any case, the current set of active shift states is available by calling an entry point in the ROM keyboard routine. The key numbers are shown on the keyboard diagram in Section 4. The following keys result in altered shift states:

Shift

This key temporarily shifts keys 2–13, 15–27, 30–41, 43–53, 55, 59–68 to uppercase (base case if in Caps Lock state). Also, the Shift key temporarily reverses the Num Lock or non-Num-Lock state of keys 71–73, 75, 77, and 79–83.

Ctrl

This key temporarily shifts keys 3, 7, 12, 14, 16–28, 30–38, 43–50, 55, 59–71, 73, 75, 77, 79, and 81 to the Ctrl state. Also, the Ctrl key is used with the Alt and Del keys to cause the system reset function, with the Scroll Lock key to cause the break function, and with the Num Lock key to cause the pause function. The system reset, break, and pause functions are described in "Special Handling" on the following pages.

Alt

This key temporarily shifts keys 2–13, 16–25, 30–38, 44–50, and 59–68 to the Alt state. Also, the Alt key is used with the Ctrl and Del keys to cause the "system reset" function described in "Special Handling" on the following pages.

The Alt key has another use. This key allows the user to enter any ASCII character code from 0 to 255 into the system from the keyboard. The user holds down the Alt key and types the decimal value of the characters desired using the numeric keypad (keys 71–73, 75–77, and 79–82). The Alt key is then released. If more than three digits are typed, a modulo-256 result is created. These three digits are interpreted as a character code and are transmitted through the keyboard routine to the system or application program. Alt is handled within the keyboard routine.

Caps Lock

This key shifts keys 16–25, 30–38, and 44–50 to uppercase. Pressing the Caps Lock key a second time reverses the action. Caps Lock is handled within the keyboard routine.

Scroll Lock

This key is interpreted by appropriate application programs as indicating that use of the cursor-control keys should cause windowing over the text rather than cursor movement. Pressing the Scroll Lock key a second time reverses the action. The keyboard routine simply records the current shift state of the Scroll Lock key. It is the responsibility of the system or application program to perform the function.

Shift Key Priorities and Combinations

If combinations of the Alt, Ctrl, and Shift keys are pressed and only one is valid, the precedence is as follows: the Alt key is first, the Ctrl key is second, and the Shift key is third. The only valid combination is Alt and Ctrl, which is used in the system reset function.

Special Handling

System Reset

The combination of the Alt, Ctrl, and Del keys will result in the keyboard routine initiating the equivalent of a system reset. System reset is handled within the keyboard routine.

Break

The combination of the Ctrl and Break keys will result in the keyboard routine signaling interrupt hex 1A. Also the extended characters (AL = hex 00, AH = hex 00) will be returned.

Pause

The combination of the Ctrl and Num Lock keys will cause the keyboard interrupt routine to loop, waiting for any key except the Num Lock key to be pressed. This provides a system- or application-transparent method of temporarily suspending list, print, and so on, and then resuming the operation. The "unpause" key is thrown away. Pause is handled within the keyboard routine.

Print Screen

The combination of the Shift and PrtSc (key 55) keys will result in an interrupt invoking the print screen routine. This routine works in the alphanumeric or graphics mode, with unrecognizable characters printing as blanks.

Extended Functions

The keyboard routine does its own buffering. The keyboard buffer is large enough that few typists will ever fill it. However, if a key is pressed when the buffer is full, the key will be ignored and the "bell" will sound.

Also, the keyboard routine suppresses the typematic action of the following keys: Ctrl, Shift, Alt, Num Lock, Scroll Lock, Caps Lock, and Ins.

Keyboard Usage

This section is intended to outline a set of guidelines of key usage when performing commonly used functions.

Function	Key(s)	Comment
Home Cursor	Home	Editors; word processors
Return to outermost menu	Home	Menu driven applications
Move cursor up	↑	Full screen editor, word processor
Page up, scroll backward 25 lines and home	PgUp	Editors; word processors
Move cursor left	←Key 75	Text, command entry
Move cursor right	→	Text, command entry
Scroll to end of text Place cursor at end of line	End	Editors; word processors
Move cursor down	↓	Full screen editor, word processor
Page down, scroll forward 25 lines and home	Pg Dn	Editors; word processors
Start/Stop insert text at cursor, shift text right in buffer	Ins	Text, command entry
Delete character at cursor	Del	Text, command entry
Destructive backspace	←Key 14	Text, command entry
Tab forward	→|	Text entry
Tab reverse	|←	Text entry
Clear screen and home	Ctrl Home	Command entry
Scroll up	↑	In scroll lock mode
Scroll down	↓	In scroll lock mode
Scroll left	←	In scroll lock mode
Scroll right	→	In scroll lock mode
Delete from cursor to EOL	Ctrl End	Text, command entry
Exit/Escape	Esc	Editor, 1 level of menu, and so on
Start/Stop Echo screen to printer	Ctrl Prt Sc (Key 55)	Any time
Delete from cursor to EOS	Ctrl PgDn	Text, command entry
Advance word	Ctrl →	Text entry
Reverse word	Ctrl ←	Text entry
Window Right	Ctrl →	When text is too wide to fit screen
Window Left	Ctrl ←	When text is too wide to fit screen
Enter insert mode	Ins	Line editor

Keyboard - Commonly Used Functions (Part 1 of 2)

Function	Key(s)	Comment
Exit insert mode	Ins	Line editor
Cancel current line	Esc	Command entry, text entry
Suspend system (pause)	Ctrl Num Lock	Stop list, stop program, and so on Resumes on any key
Break interrupt	Ctrl Break	Interrupt current process
System reset	Alt Ctrl Del	Reboot
Top of document and home cursor	Ctrl PgUp	Editors, word processors
Standard function keys	F1-F10	Primary function keys
Secondary function keys	Shift F1-F10 Ctrl F1-F10 Alt F1-F10	Extra function keys if 10 are not sufficient
Extra function keys	Alt Keys 2-13 (1-9,0,-, =)	Used when templates are put along top of keyboard
Extra function keys	Alt A-Z	Used when function starts with same letter as one of the alpha keys

Keyboard - Commonly Used Functions (Part 2 of 2)

Function	Key
Carriage return	←┘
Line feed	Ctrl ←┘
Bell	Ctrl G
Home	Home
Cursor up	↑
Cursor down	↓
Cursor left	←
Cursor right	→
Advance one word	Ctrl →
Reverse one word	Ctrl ←
Insert	Ins
Delete	Del
Clear screen	Ctrl Home
Freeze output	Ctrl Num Lock
Tab advance	→|
Stop execution (break)	Ctrl Break
Delete current line	Esc
Delete to end of line	Ctrl End
Position cursor to end of line	End

BASIC Screen Editor Special Functions

Function	Key
Suspend	Ctrl Num Lock
Echo to printer	Ctrl PrtSc (Key 55 any case)
Stop echo to printer	Ctrl PrtSc (Key 55 any case)
Exit current function (break)	Ctrl Break
Backspace	← Key 14
Line feed	Ctrl←┘
Cancel line	Esc
Copy character	F1 or →
Copy until match	F2
Copy remaining	F3
Skip character	Del
Skip until match	F4
Enter insert mode	Ins
Exit insert mode	Ins
Make new line the template	F5
String separator in REPLACE	F6
End of file in keyboard input	F6

DOS Special Functions

BIOS Cassette Logic

Software Algorithms - Interrupt Hex 15

The cassette routine is called by the request type in AH. The address of the bytes to be read from or written to the tape is specified ES:BX and the number of bytes to be read or written is specified by CX. The number of bytes read is returned in DX. The read block and write block automatically turn the cassette motor on at the start and off at the end. The request types in AH and the cassette status descriptions follow:

Request Type	Function
AH = 0	Turn Cassette Motor On
AH = 1	Turn Cassette Motor Off
AH = 2	Read Tape Block Read CX bytes into memory starting at Address ES:BX Return actual number of bytes read in DX Return Cassette Status in AH
AH = 3	Write Tape Block Write CX bytes onto cassette starting at Address DS:BX Return Cassette Status in AH

Cassette Status	Description
AH = 00	No Errors
AH = 01	Cyclic Redundancy Check (CRC) Error in Read Block
AH = 02	No Data Transitions
AH = 04	No Leader
AH = 80	Invalid Command
Notes: The carry flag will be set on any error.	

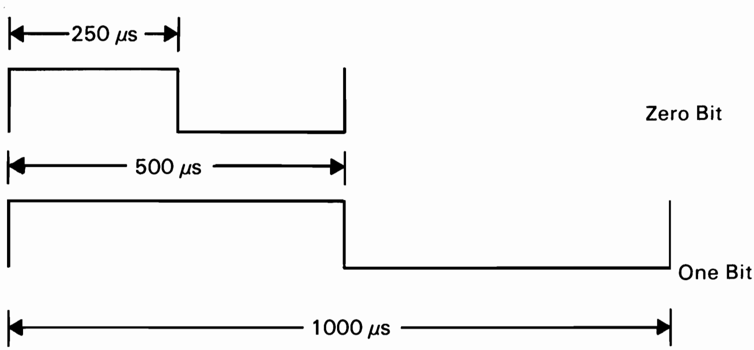
Cassette Write

The write-block routine writes a tape block onto the cassette tape. The tape block is described in "Data Record Architecture" later in this section.

The write-block routine turns on the cassette drive motor and a synchronization bit(0) and then writes the leader(256 bytes of all 1's) to the tape. Next, the routine writes the number of data blocks specified by CX. After each data block of 256 bytes, a 2-byte cyclic redundancy check (CRC) is written. The data bytes are taken from the memory location pointed at by ES.

The write-byte routine disassembles and writes the byte a bit at a time to the cassette. The method used is to set Timer 2 to the period of the desired data bit. The timer is set to a period of 1.0-ms for a 1 bit and 0.5-ms for a 0 bit.

The timer is set to mode 3, which means the timer outputs a square wave with a period given by its count register. The timer's period is changed on the fly for each data bit written to the cassette. If the number of data bytes to be written is not an integral multiple of 256, then, after the last desired data byte from memory has been written, the data block is extended to 256 bytes of writing multiples of the last data byte. The last block is closed with two CRC bytes as usual. After the last data block, a trailer consisting of four bytes of all 1 bits is written. Finally, the cassette motor is turned off, if there are no errors reported by the routine.



Cassette Read

The read-block routine turns on the cassette drive motor and then delays for about 0.5 second to allow the motor to come up to speed.

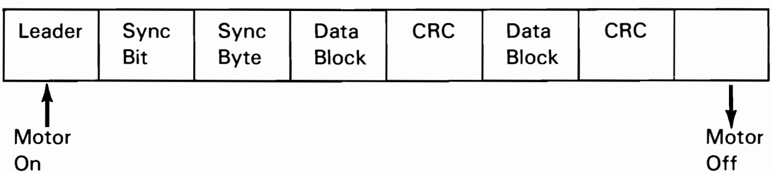
The read-block routine then searches for the leader and must detect all 1 bits for approximately 1/4 of the leader length before it can look for the sync (0) bit. After the sync bit is detected, the sync byte (ASCII character hex 16) is read. If the sync byte is read correctly, the data portion can be read. If a correct sync byte is not found, the routine goes back and searches for the leader again. The data is read a bit at a time and assembled into bytes. After each byte is assembled, it is written into memory at location ES:BX and BX is incremented by 1.

After each multiple of 256 data bytes is read, the CRC is read and compared to the CRC generated. If a CRC error is detected, the routine exits with the carry flag set to indicate an error and the status of AH set to hex 01. DX contains the number of bytes written to memory.

The time of day interrupt(IRQ0) is disabled during the cassette-read operation.

Data Record Architecture

The write-block routine uses the following format to record a tape block onto a cassette tape.



Component	Description
Leader	256 Bytes (of All 1's)
Sync Bit	One 0 Bit
Sync Byte	ASCII Character Hex 16
Data Blocks	256 Bytes in Length
CRC	2 Bytes for each Data Block

Data Record Components

Error Recovery

Error recovery is handled through software. A CRC is used to detect errors. The polynomial used is $G(X) = X^{16}+X^{12}+X^{5}+1$, which is the polynomial used by the synchronous data link control interface. Essentially, as bits are written to or read from the cassette tape, they are passed through the CRC register in software. After a block of data is written, the complemented value of the calculated CRC register is written on the tape. On reading the cassette data, the CRC bytes are read and compared to the generated CRC value. If the read CRC does not equal the generated CRC, the processor's carry flag is set and the status of AH is set to hex 01, which indicates a CRC error has occurred. The routine is exited on a CRC error.

System BIOS Listing

Quick Reference

Section 5

```
LOC OBJ          LINE    SOURCE

                 $TITLE(BIOS FOR IBM PERSONAL COMPUTER)

                 ;---------------------------------------------------------------
                 ;       THE  BIOS ROUTINES ARE MEANT TO BE ACCESSED THROUGH     :
                 ;       SOFTWARE INTERRUPTS ONLY.  ANY ADDRESSES PRESENT IN     :
                 ;       THE LISTINGS  ARE INCLUDED  ONLY FOR  COMPLETENESS,     :
                 ;       NOT FOR  REFERENCE.   APPLICATIONS WHICH  REFERENCE     :
                 ;       ABSOLUTE   ADDRESSES   WITHIN   THE  CODE   SEGMENT     :
                 ;       VIOLATE THE STRUCTURE AND DESIGN OF BIOS.               :
                 ;---------------------------------------------------------------

                 ;----------------------------------------
                 ;               EQUATES                 :
                 ;----------------------------------------
 0060            PORT_A          EQU     60H             ; 8255 PORT A ADDR
 0061            PORT_B          EQU     61H             ; 8255 PORT B ADDR
 0062            PORT_C          EQU     62H             ; 8255 PORT C ADDR
 0063            CMD_PORT        EQU     63H
 0020            INTA00          EQU     20H             ; 8259 PORT
 0021            INTA01          EQU     21H             ; 8259 PORT
 0020            EOI             EQU     20H
 0040            TIMER           EQU     40H
 0043            TIM_CTL         EQU     43H             ; 8253 TIMER CONTROL PORT ADDR
 0040            TIMER0          EQU     40H             ; 8253 TIMER/CNTER 0 PORT ADDR
 0001            TMINT           EQU     01              ; TIMER 0 INTR RECVD MASK
 0008            DMA08           EQU     08              ; DMA STATUS REG PORT ADDR
 0000            DMA             EQU     00              ; DMA CHANNEL 0 ADDR REG PORT ADDR
 0540            MAX_PERIOD      EQU     540H
 0410            MIN_PERIOD      EQU     410H
 0060            KBD_IN          EQU     60H             ; KEYBOARD DATA IN ADDR PORT
 0002            KBDINT          EQU     02              ; KEYBOARD INTR MASK
 0060            KB_DATA         EQU     60H             ; KEYBOARD SCAN CODE PORT
 0061            KB_CTL          EQU     61H             ; CONTROL BITS FOR KB SENSE DATA
                 ;----------------------------------------
                 ;       8088 INTERRUPT LOCATIONS        :
                 ;----------------------------------------
----             ABS0            SEGMENT AT 0
0000             STG_LOC0        LABEL   BYTE
0008                             ORG     2*4
0008             NMI_PTR         LABEL   WORD
0014                             ORG     5*4
0014             INT5_PTR        LABEL   WORD
0020                             ORG     8*4
0020             INT_ADDR        LABEL   WORD
0020             INT_PTR         LABEL   DWORD
0040                             ORG     10H*4
0040             VIDEO_INT       LABEL   WORD
0074                             ORG     1DH*4
0074             PARM_PTR        LABEL   DWORD           ; POINTER TO VIDEO PARMS
0060                             ORG     18H*4
0060             BASIC_PTR       LABEL   WORD            ; ENTRY POINT FOR CASSETTE BASIC
0078                             ORG     01EH*4          ; INTERRUPT 1EH
0078             DISK_POINTER    LABEL   DWORD
007C                             ORG     01FH*4          ; LOCATION OF POINTER
007C             EXT_PTR LABEL   DWORD                   ; POINTER TO EXTENSION
0100                             ORG     040H*4          ; ROUTINE
0100 ????        IO_ROM_INIT     DW      ?               ;
0102 ????        IO_ROM_SEG      DW      ?               ; OPTIONAL ROM SEGMENT
0400                             ORG     400H
0400             DATA_AREA       LABEL   BYTE            ; ABSOLUTE LOCATION OF DATA SEGMENT
0400             DATA_WORD       LABEL   WORD
7C00                             ORG     7C00H
7C00             BOOT_LOCN       LABEL   FAR
----             ABS0            ENDS

                 ;-------------------------------------------------------
                 ;       STACK -- USED DURING INITIALIZATION ONLY       :
                 ;-------------------------------------------------------
----             STACK           SEGMENT AT 30H
0000 (128                        DW      128 DUP(?)
     ????
     )
0100             TOS             LABEL   WORD
----             STACK           ENDS

                 ;----------------------------------------
                 ;       ROM BIOS DATA AREAS             :
                 ;----------------------------------------
----             DATA            SEGMENT AT 40H
```

```
LOC OBJ          SOURCE

0000 (4          RS232_BASE      DW      4 DUP(?)        ; ADDRESSES OF RS232 ADAPTERS
     ????
     )
0008 (4          PRINTER_BASE    DW      4 DUP(?)        ; ADDRESSES OF PRINTERS
     ????
     )
0010 ????        EQUIP_FLAG      DW      ?               ; INSTALLED HARDWARE
0012 ??          MFG_TST         DB      ?               ; INITIALIZATION FLAG
0013 ????        MEMORY_SIZE     DW      ?               ; MEMORY SIZE IN K BYTES
0015 ????        IO_RAM_SIZE     DW      ?               ; MEMORY IN I/O CHANNEL
                 ;----------------------------------------
                 ;          KEYBOARD DATA AREAS          :
                 ;----------------------------------------
0017 ??          KB_FLAG         DB      ?

                 ;----- SHIFT FLAG EQUATES WITHIN KB_FLAG

 0080            INS_STATE       EQU     80H             ; INSERT STATE IS ACTIVE
 0040            CAPS_STATE      EQU     40H             ; CAPS LOCK STATE HAS BEEN TOGGLED
 0020            NUM_STATE       EQU     20H             ; NUM LOCK STATE HAS BEEN TOGGLED
 0010            SCROLL_STATE    EQU     10H             ; SCROLL LOCK STATE HAS BEEN TOGGLED
 0008            ALT_SHIFT       EQU     08H             ; ALTERNATE SHIFT KEY DEPRESSED
 0004            CTL_SHIFT       EQU     04H             ; CONTROL SHIFT KEY DEPRESSED
 0002            LEFT_SHIFT      EQU     02H             ; LEFT SHIFT KEY DEPRESSED
 0001            RIGHT_SHIFT     EQU     01H             ; RIGHT SHIFT KEY DEPRESSED

0018 ??          KB_FLAG_1       DB      ?               ; SECOND BYTE OF KEYBOARD STATUS

 0080            INS_SHIFT       EQU     80H             ; INSERT KEY IS DEPRESSED
 0040            CAPS_SHIFT      EQU     40H             ; CAPS LOCK KEY IS DEPRESSED
 0020            NUM_SHIFT       EQU     20H             ; NUM LOCK KEY IS DEPRESSED
 0010            SCROLL_SHIFT    EQU     10H             ; SCROLL LOCK KEY IS DEPRESSED
 0008            HOLD_STATE      EQU     08H             ; SUSPEND KEY HAS BEEN TOGGLED

0019 ??          ALT_INPUT       DB      ?               ; STORAGE FOR ALTERNATE KEYPAD ENTRY
001A ????        BUFFER_HEAD     DW      ?               ; POINTER TO HEAD OF KEYBOARD BUFFER
001C ????        BUFFER_TAIL     DW      ?               ; POINTER TO TAIL OF KEYBOARD BUFFER
001E (16         KB_BUFFER       DW      16 DUP(?)       ; ROOM FOR 15 ENTRIES
     ????
     )
003E             KB_BUFFER_END   LABEL   WORD

                 ;----- HEAD = TAIL INDICATES THAT THE BUFFER IS EMPTY

 0045            NUM_KEY         EQU     69              ; SCAN CODE FOR NUMBER LOCK
 0046            SCROLL_KEY      EQU     70              ; SCROLL LOCK KEY
 0038            ALT_KEY         EQU     56              ; ALTERNATE SHIFT KEY SCAN CODE
 001D            CTL_KEY         EQU     29              ; SCAN CODE FOR CONTROL KEY
 003A            CAPS_KEY        EQU     58              ; SCAN CODE FOR SHIFT LOCK
 002A            LEFT_KEY        EQU     42              ; SCAN CODE FOR LEFT SHIFT
 0036            RIGHT_KEY       EQU     54              ; SCAN CODE FOR RIGHT SHIFT
 0052            INS_KEY         EQU     82              ; SCAN CODE FOR INSERT KEY
 0053            DEL_KEY         EQU     83              ; SCAN CODE FOR DELETE KEY

                 ;----------------------------------------
                 ;       DISKETTE DATA AREAS             :
                 ;----------------------------------------
003E ??          SEEK_STATUS     DB      ?               ; DRIVE RECALIBRATION STATUS
                 ;                               BIT 3-0 = DRIVE 3-0 NEEDS RECAL BEFORE
                 ;                                         NEXT SEEK IF BIT IS = 0
 0080            INT_FLAG        EQU     080H            ; INTERRUPT OCCURRENCE FLAG
003F ??          MOTOR_STATUS    DB      ?               ; MOTOR STATUS
                 ;                               BIT 3-0 = DRIVE 3-0 IS CURRENTLY RUNNING
                 ;                               BIT 7   = CURRENT OP IS A WRITE, REQUIRES DELAY
0040 ??          MOTOR_COUNT     DB      ?               ; TIME OUT COUNTER FOR DRIVE TURN OFF
 0025            MOTOR_WAIT      EQU     37              ; TWO SEC OF COUNT FOR MOTOR TURN OFF

0041 ??          DISKETTE_STATUS DB      ?               ; BYTE OF RETURN CODE INFO FOR STATUS
 0080            TIME_OUT        EQU     80H             ; ATTACHMENT FAILED TO RESPOND
 0040            BAD_SEEK        EQU     40H             ; SEEK OPERATION FAILED
 0020            BAD_NEC         EQU     20H             ; NEC CONTROLLER HAS FAILED
 0010            BAD_CRC         EQU     10H             ; BAD CRC ON DISKETTE READ
 0009            DMA_BOUNDARY    EQU     09H             ; ATTEMPT TO DMA ACROSS 64K BOUNDARY
 0008            BAD_DMA         EQU     08H             ; DMA OVERRUN ON OPERATION
 0004            RECORD_NOT_FND  EQU     04H             ; REQUESTED SECTOR NOT FOUND
 0003            WRITE_PROTECT   EQU     03H             ; WRITE ATTEMPTED ON WRITE PROT DISK
 0002            BAD_ADDR_MARK   EQU     02H             ; ADDRESS MARK NOT FOUND
```

```
LOC OBJ                 SOURCE

 0001                   BAD_CMD         EQU     01H             ; BAD COMMAND PASSED TO DISKETTE I/O

0042 (7                 NEC_STATUS      DB      7 DUP(?)        ; STATUS BYTES FROM NEC
      ??
     )

                        ;----------------------------------------
                        ;       VIDEO DISPLAY DATA AREA         :
                        ;----------------------------------------
0049 ??                 CRT_MODE        DB      ?               ; CURRENT CRT MODE
004A ????               CRT_COLS        DW      ?               ; NUMBER OF COLUMNS ON SCREEN
004C ????               CRT_LEN         DW      ?               ; LENGTH OF REGEN IN BYTES
004E ????               CRT_START       DW      ?               ; STARTING ADDRESS IN REGEN BUFFER
0050 (8                 CURSOR_POSN     DW      8 DUP(?)        ; CURSOR FOR EACH OF UP TO 8 PAGES
      ????
     )
0060 ????               CURSOR_MODE     DW      ?               ; CURRENT CURSOR MODE SETTING
0062 ??                 ACTIVE_PAGE     DB      ?               ; CURRENT PAGE BEING DISPLAYED
0063 ????               ADDR_6845       DW      ?               ; BASE ADDRESS FOR ACTIVE DISPLAY CARD
0065 ??                 CRT_MODE_SET    DB      ?               ; CURRENT SETTING OF THE 3X8 REGISTER
0066 ??                 CRT_PALETTE     DB      ?               ; CURRENT PALETTE SETTING COLOR CARD

                        ;----------------------------------------
                        ;          CASSETTE DATA AREA           :
                        ;----------------------------------------
0067 ????               EDGE_CNT        DW      ?               ; TIME COUNT AT DATA EDGE
0069 ????               CRC_REG         DW      ?               ; CRC REGISTER
006B ??                 LAST_VAL        DB      ?               ; LAST INPUT VALUE

                        ;----------------------------------------
                        ;           TIMER DATA AREA             :
                        ;----------------------------------------
006C ????               TIMER_LOW       DW      ?               ; LOW WORD OF TIMER COUNT
006E ????               TIMER_HIGH      DW      ?               ; HIGH WORD OF TIMER COUNT
0070 ??                 TIMER_OFL       DB      ?               ; TIMER HAS ROLLED OVER SINCE LAST READ
                        ;COUNTS_SEC     EQU     18
                        ;COUNTS_MIN     EQU     1092
                        ;COUNTS_HOUR    EQU     65543
                        ;COUNTS_DAY     EQU     1573040 = 1800B0H

                        ;----------------------------------------
                        ;          SYSTEM DATA AREA             :
                        ;----------------------------------------
0071 ??                 BIOS_BREAK      DB      ?               ; BIT 7 = 1 IF BREAK KEY WAS DEPRESSED
0072 ????               RESET_FLAG      DW      ?               ; WORD = 1234H IF KB RESET UNDERWAY
                        ;----------------------------------------
                        ;         FIXED DISK DATA AREA          :
                        ;----------------------------------------
0074 ????                               DW      ?               ;
0076 ????                               DW      ?               ;
                        ;----------------------------------------
                        ;       PRINTER AND RS232 TIMEOUT CTRS  :
                        ;----------------------------------------
0078 (4                 PRINT_TIM_OUT   DB      4 DUP(?)        ; PRINTER TIME OUT COUNTER
      ??
     )
007C (4                 RS232_TIM_OUT   DB      4 DUP(?)        ; RS232 TIME OUT COUNTER
      ??
     )
                        ;----------------------------------------
                        ;       EXTRA KEYBOARD DATA AREA        :
                        ;----------------------------------------
0080 ????               BUFFER_START    DW      ?
0082 ????               BUFFER_END      DW      ?
----                    DATA    ENDS
                        ;----------------------------------------
                        ;           EXTRA DATA AREA             :
                        ;----------------------------------------
----                    XXDATA          SEGMENT AT 50H
0000 ??                 STATUS_BYTE     DB      ?
----                    XXDATA          ENDS

                        ;----------------------------------------
                        ;       VIDEO DISPLAY BUFFER            :
                        ;----------------------------------------
----                    VIDEO_RAM       SEGMENT AT 0B800H
```

```
LOC OBJ                SOURCE

0000                   REGEN           LABEL   BYTE
0000                   REGENW          LABEL   WORD
0000 (16384                            DB      16384 DUP(?)
     ??
     )
----                   VIDEO_RAM       ENDS
                       ;----------------------------------------
                       ;        ROM RESIDENT CODE              :
                       ;----------------------------------------
----                   CODE            SEGMENT AT 0F000H
0000 (57344                            DB      57344 DUP(?)                ; FILL LOWEST 56K
     ??
     )

E000 31353031343736                    DB      '1501476 COPR. IBM 1981'    ; COPYRIGHT NOTICE
     20434F50522E20
     49424D20313938
     32

                       ;------------------------------------------------------------
                       ;       INITIAL RELIABILITY TESTS -- PHASE 1               :
                       ;------------------------------------------------------------
                                       ASSUME   CS:CODE,SS:CODE,ES:ABS0,DS:DATA
                       ;----------------------------------------
                       ;       DATA DEFINITIONS                :
                       ;----------------------------------------
E016 D1E0              C1      DW      C11             ; RETURN ADDRESS

                       ;-------------------------------------------------------------------
                       ;       THIS SUBROUTINE PERFORMS A READ/WRITE STORAGE TEST ON      :
                       ;       A 16K BLOCK OF STORAGE.                                    :
                       ; ENTRY REQUIREMENTS:                                              :
                       ;       ES = ADDRESS OF STORAGE SEGMENT BEING TESTED               :
                       ;       DS = ADDRESS OF STORAGE SEGMENT BEING TESTED               :
                       ;       WHEN ENTERING AT STGTST_CNT, CX MUST BE LOADED WITH        :
                       ;       THE BYTE COUNT.                                            :
                       ; EXIT PARAMETERS:                                                 :
                       ;       ZERO FLAG = 0 IF STORAGE ERROR (DATA COMPARE OR PARITY CHECK.  :
                       ;               AL = 0 DENOTES A PARITY CHECK. ELSE AL=XOR'ED BIT  :
                       ;                       PATTERN OF THE EXPECTED DATA PATTERN VS THE  :
                       ;                       ACTUAL DATA READ.                          :
                       ;       AX,BX,CX,DX,DI, AND SI ARE ALL DESTROYED.                  :
                       ;-------------------------------------------------------------------

E018                   STGTST  PROC    NEAR
E018 B90040                    MOV     CX,4000H                ; SETUP CNT TO TEST A 16K BLK
E01B                   STGTST_CNT:
E01B FC                        CLD                             ; SET DIR FLAG TO INCREMENT
E01C 8BD9                      MOV     BX,CX                   ; SAVE BYTE CNT (4K FOR VIDEO OR 16K)
E01E B8AAAA                    MOV     AX,0AAAAH               ; GET DATA PATTERN TO WRITE
E021 BA55FF                    MOV     DX,0FF55H               ; SETUP OTHER DATA PATTERNS TO USE
E024 2BFF                      SUB     DI,DI                   ; DI = OFFSET 0 RELATIVE TO ES REG
E026 F3                        REP     STOSB                   ; WRITE STORAGE LOCATIONS
E027 AA
E028                   C3:                                     ;  STG01
E028 4F                        DEC     DI                      ; POINT TO LAST BYTE JUST WRITTEN
E029 FD                        STD                             ; SET DIR FLAG TO GO BACKWARDS
E02A                   C4:
E02A 8BF7                      MOV     SI,DI
E02C 8BCB                      MOV     CX,BX                   ; SETUP BYTE CNT
E02E                   C5:                                     ; INNER TEST LOOP
E02E AC                        LODSB                           ; READ OLD TST BYTE FROM STORAGE [SI]+
E02F 32C4                      XOR     AL,AH                   ; DATA READ AS EXPECTED ?
E031 7525                      JNE     C7                      ;  NO - GO TO ERROR ROUTINE
E033 8AC2                      MOV     AL,DL                   ; GET NEXT DATA PATTERN TO WRITE
E035 AA                        STOSB                           ; WRITE INTO LOCATION JUST READ [DI]+
E036 E2F6                      LOOP    C5                      ;  DECREMENT BYTE COUNT AND LOOP CX

E038 22E4                      AND     AH,AH                   ; ENDING ZERO PATTERN WRITTEN TO STG ?
E03A 7416                      JZ      C6X                     ; YES - RETURN TO CALLER WITH AL=0
E03C 8AE0                      MOV     AH,AL                   ; SETUP NEW VALUE FOR COMPARE
E03E 86F2                      XCHG    DH,DL                   ; MOVE NEXT DATA PATTERN TO DL
E040 22E4                      AND     AH,AH                   ; READING ZERO PATTERN THIS PASS ?
E042 7504                      JNZ     C6                      ; CONTINUE TEST SEQUENCE TILL ZERO DATA
E044 8AD4                      MOV     DL,AH                   ;  ELSE SET ZERO FOR END READ PATTERN
E046 EBE0                      JMP     C3                      ;  AND MAKE FINAL BACKWARDS PASS
E048                   C6:
```

Section 5

```
LOC OBJ                  SOURCE

E048 FC                          CLD                              ; SET DIR FLAG TO GO FORWARD
E049 47                          INC     DI                       ; SET POINTER TO BEG LOCATION
E04A 74DE                        JZ      C4                       ; READ/WRITE FORWARD IN STG
E04C 4F                          DEC     DI                       ; ADJUST POINTER
E04D BA0100                      MOV     DX,00001H                ; SETUP 01 FOR PARITY BIT
                                                                  ;  AND 00 FOR END
E050 EBD6                        JMP     C3                       ; READ/WRITE BACKWARD IN STG
E052                     C6X:
E052 E462                        IN      AL,PORT_C                ; DID A PARITY ERROR OCCUR ?
E054 24C0                        AND     AL,0C0H                  ; ZERO FLAG WILL BE OFF PARITY ERROR
E056 B000                        MOV     AL,000H                  ; AL=0 DATA COMPARE OK
E058                     C7:
E058 FC                          CLD                              ; SET DEFAULT DIRCTN FLAG BACK TO INC
E059 C3                          RET
                         STGTST  ENDP
                         ;--------------------------------------------------------------
                         ;       8088 PROCESSOR TEST                                  :
                         ; DESCRIPTION                                                :
                         ;       VERIFY 8088 FLAGS, REGISTERS AND CONDITIONAL JUMPS   :
                         ;--------------------------------------------------------------
                                 ASSUME  CS:CODE,DS:NOTHING,ES:NOTHING,SS:NOTHING
E05B                             ORG     0E05BH
E05B                     RESET   LABEL   FAR
E05B                     START:
E05B FA                          CLI                              ; DISABLE INTERRUPTS
E05C B4D5                        MOV     AH,0D5H                  ; SET SF, CF, ZF, AND AF FLAGS ON
E05E 9E                          SAHF
E05F 734C                        JNC     ERR01                    ; GO TO ERR ROUTINE IF CF NOT SET
E061 754A                        JNZ     ERR01                    ; GO TO ERR ROUTINE IF ZF NOT SET
E063 7B48                        JNP     ERR01                    ; GO TO ERR ROUTINE IF PF NOT SET
E065 7946                        JNS     ERR01                    ; GO TO ERR ROUTINE IF SF NOT SET
E067 9F                          LAHF                             ; LOAD FLAG IMAGE TO AH
E068 B105                        MOV     CL,5                     ; LOAD CNT REG WITH SHIFT CNT
E06A D2EC                        SHR     AH,CL                    ; SHIFT AF INTO CARRY BIT POS
E06C 733F                        JNC     ERR01                    ; GO TO ERR ROUTINE IF AF NOT SET
E06E B040                        MOV     AL,40H                   ; SET THE OF FLAG ON
E070 D0E0                        SHL     AL,1                     ; SETUP FOR TESTING
E072 7139                        JNO     ERR01                    ; GO TO ERR ROUTINE IF OF NOT SET
E074 32E4                        XOR     AH,AH                    ; SET AH = 0
E076 9E                          SAHF                             ; CLEAR SF, CF, ZF, AND PF
E077 7634                        JBE     ERR01                    ; GO TO ERR ROUTINE IF CF ON
                                                                  ; OR TO TO ERR ROUTINE IF ZF ON
E079 7832                        JS      ERR01                    ; GO TO ERR ROUTINE IF SF ON
E07B 7A30                        JP      ERR01                    ; GO TO ERR ROUTINE IF PF ON
E07D 9F                          LAHF                             ; LOAD FLAG IMAGE TO AH
E07E B105                        MOV     CL,5                     ; LOAD CNT REG WITH SHIFT CNT
E080 D2EC                        SHR     AH,CL                    ; SHIFT 'AF' INTO CARRY BIT POS
E082 7229                        JC      ERR01                    ; GO TO ERR ROUTINE IF ON
E084 D0E4                        SHL     AH,1                     ; CHECK THAT 'OF' IS CLEAR
E086 7025                        JO      ERR01                    ; GO TO ERR ROUTINE IF ON

                         ;----- READ/WRITE THE 8088 GENERAL AND SEGMENTATION REGISTERS
                         ;        WITH ALL ONE'S AND ZEROES'S.

E088 B8FFFF                      MOV     AX,0FFFFH                ; SETUP ONE'S PATTERN IN AX
E08B F9                          STC
E08C                     C8:
E08C 8ED8                        MOV     DS,AX                    ; WRITE PATTERN TO ALL REGS
E08E 8CDB                        MOV     BX,DS
E090 8EC3                        MOV     ES,BX
E092 8CC1                        MOV     CX,ES
E094 8ED1                        MOV     SS,CX
E096 8CD2                        MOV     DX,SS
E098 8BE2                        MOV     SP,DX
E09A 8BEC                        MOV     BP,SP
E09C 8BF5                        MOV     SI,BP
E09E 8BFE                        MOV     DI,SI
E0A0 7307                        JNC     C9                       ; TST1A
E0A2 33C7                        XOR     AX,DI                    ; PATTERN MAKE IT THRU ALL REGS
E0A4 7507                        JNZ     ERR01                    ; NO - GO TO ERR ROUTINE
E0A6 F8                          CLC
E0A7 EBE3                        JMP     C8
E0A9                     C9:                                      ; TST1A
E0A9 0BC7                        OR      AX,DI                    ; ZERO PATTERN MAKE IT THRU?
E0AB 7401                        JZ      C10                      ; YES - GO TO NEXT TEST
E0AD F4                  ERR01:  HLT                              ; HALT SYSTEM
                         ;-------------------------------------------------------
```

```
LOC OBJ           LINE    SOURCE

                          ;       ROS CHECKSUM TEST I                           :
                          ; DESCRIPTION                                         :
                          ;       A CHECKSUM IS DONE FOR THE 8K ROS MODULE      :
                          ;       CONTAINING POD AND BIOS.                      :
                          ;-----------------------------------------------------
E0AE                      C10:
                                                          ; ZERO IN AL ALREADY
E0AE E6A0                         OUT     0A0H,AL         ; DISABLE NMI INTERRUPTS
E0B0 E683                         OUT     83H,AL          ; INITIALZE DMA PAGE REG
E0B2 BAD803                       MOV     DX,3D8H
E0B5 EE                           OUT     DX,AL           ; DISABLE COLOR VIDEO
E0B6 FEC0                         INC     AL
E0B8 B2B8                         MOV     DL,0B8H
E0BA EE                           OUT     DX,AL           ; DISABLE B/W VIDEO,EN HIGH RES
E0BB B099                         MOV     AL,99H          ; SET 8255 A,C-INPUT,B-OUTPUT
E0BD E663                         OUT     CMD_PORT,AL     ; WRITE 8255 CMD/MODE REG
E0BF B0FC                         MOV     AL,0FCH         ; DISABLE PARITY CHECKERS AND
E0C1 E661                         OUT     PORT_B,AL       ;  GATE SNS SWS,CASS MOTOR OFF
E0C3 8CC8                         MOV     AX,CS           ; SETUP SS SEG REG
E0C5 8ED0                         MOV     SS,AX
E0C7 8ED8                         MOV     DS,AX           ; SET UP DATA SEG TO POINT TO
                                                          ;  ROM ADDRESS
                                  ASSUME  SS:CODE
E0C9 B7E0                         MOV     BH,0E0H         ; SETUP STARTING ROS ADDR (E0000)
E0CB BC16E0                       MOV     SP,OFFSET C1    ; SETUP RETURN ADDRESS
E0CE E97B0B                       JMP     ROS_CHECKSUM
E0D1                      C11:
E0D1 75DA                         JNE     ERR01           ; HALT SYSTEM IF ERROR
                          ;----------------------------------------------------------------
                          ;       8237 DMA INITIALIZATION CHANNEL REGISTER TEST          :
                          ; DESCRIPTION                                                  :
                          ;       DISABLE THE 8237 DMA CONTROLLER.  VERIFY THAT TIMER 1  :
                          ;       FUNCTIONS OK. WRITE/READ THE CURRENT ADDRESS AND WORD  :
                          ;       COUNT REGISTERS FOR ALL CHANNELS.  INITIALIZE AND      :
                          ;       START DMA FOR MEMORY REFRESH.                          :
                          ;----------------------------------------------------------------
E0D3 B004                         MOV     AL,04           ; DISABLE DMA CONTROLLER
E0D5 E608                         OUT     DMA08,AL

                          ;----- VERIFY THAT TIMER 1 FUNCTIONS OK

E0D7 B054                         MOV     AL,54H          ; SEL TIMER 1,LSB,MODE 2
E0D9 E643                         OUT     TIMER+3,AL
E0DB 8AC1                         MOV     AL,CL           ; SET INITIAL TIMER CNT TO 0
E0DD E641                         OUT     TIMER+1,AL
E0DF                      C12:                            ; TIMER1_BITS_ON
E0DF B040                         MOV     AL,40H          ; LATCH TIMER 1 COUNT
E0E1 E643                         OUT     TIMER+3,AL
E0E3 80FBFF                       CMP     BL,0FFH         ; YES - SEE IF ALL BITS GO OFF
E0E6 7407                         JE      C13             ; TIMER1_BITS_OFF
E0E8 E441                         IN      AL,TIMER+1      ; READ TIMER 1 COUNT
E0EA 0AD8                         OR      BL,AL           ; ALL BITS ON IN TIMER
E0EC E2F1                         LOOP    C12             ; TIMER1_BITS_ON
E0EE F4                           HLT                     ; TIMER 1 FAILURE, HALT SYS
E0EF                      C13:                            ; TIMER1_BITS_OFF
E0EF 8AC3                         MOV     AL,BL           ; SET TIMER 1 CNT
E0F1 2BC9                         SUB     CX,CX
E0F3 E641                         OUT     TIMER+1,AL
E0F5                      C14:                            ; TIMER_LOOP
E0F5 B040                         MOV     AL,40H          ; LATCH TIMER 1 COUNT
E0F7 E643                         OUT     TIMER+3,AL
E0F9 90                           NOP                     ; DELAY FOR TIMER
E0FA 90                           NOP
E0FB E441                         IN      AL,TIMER+1      ; READ TIMER 1 COUNT
E0FD 22D8                         AND     BL,AL
E0FF 7403                         JZ      C15             ; GO TO WRAP_DMA_REG
E101 E2F2                         LOOP    C14             ; TIMER_LOOP
E103 F4                           HLT                     ; TIMER ERROR - HALT SYSTEM

                          ;----- INITIALIZE TIMER 1 TO REFRESH MEMORY

E104                      C15:                            ; WRAP_DMA_REG
E104 B012                         MOV     AL,18           ; SETUP DIVISOR FOR REFRESH
E106 E641                         OUT     TIMER+1,AL      ; WRITE TIMER 1 CNT REG
E108 E60D                         OUT     DMA+0DH,AL      ; SEND MASTER CLEAR TO DMA
```

Section 5

```
LOC OBJ                 LINE    SOURCE

                        ;----- WRAP DMA CHANNELS ADDRESS AND COUNT REGISTERS

E10A B0FF                       MOV     AL,0FFH                 ; WRITE PATTERN FF TO ALL REGS
E10C                    C16:
E10C 8AD8                       MOV     BL,AL                   ; SAVE PATTERN FOR COMPARE
E10E 8AF8                       MOV     BH,AL
E110 B90800                     MOV     CX,8                    ; SETUP LOOP CNT
E113 2BD2                       SUB     DX,DX                   ; SETUP I/O PORT ADDR OF REG (0000)
E115                    C17:
E115 EE                         OUT     DX,AL                   ; WRITE PATTERN TO REG, LSB
E116 50                         PUSH    AX
E117 EE                         OUT     DX,AL                   ; MSB OF 16 BIT REG
E118 B80101                     MOV     AX,0101H                ; AX TO ANOTHER PAT BEFORE RD
E11B EC                         IN      AL,DX                   ; READ 16-BIT DMA CH REG, LSB
E11C 8AE0                       MOV     AH,AL                   ; SAVE LSB OF 16-BIT REG
E11E EC                         IN      AL,DX                   ; READ MSB OF DMA CH REG
E11F 3BD8                       CMP     BX,AX                   ; PATTERN READ AS WRITTEN?
E121 7401                       JE      C18                     ; YES - CHECK NEXT REG
E123 F4                         HLT                             ; NO - HALT THE SYSTEM
E124                    C18:                                    ; NXT_DMA_CH
E124 42                         INC     DX                      ; SET I/O PORT TO NEXT CH REG
E125 E2EE                       LOOP    C17                     ; WRITE PATTERN TO NEXT REG
E127 FEC0                       INC     AL                      ; SET PATTERN TO 0
E129 74E1                       JZ      C16                     ; WRITE TO CHANNEL REGS

                        ;----- INITIALIZE AND START DMA FOR MEMORY REFRESH.

E12B 8EDB                       MOV     DS,BX                   ; SET UP ABS0 INTO DS AND ES
E12D 8EC3                       MOV     ES,BX
                                ASSUME  DS:ABS0,ES:ABS0

E12F B0FF                       MOV     AL,0FFH                 ; SET CNT OF 64K FOR RAM REFRESH
E131 E601                       OUT     DMA+1,AL
E133 50                         PUSH    AX
E134 E601                       OUT     DMA+1,AL
E136 B20B                       MOV     DL,0BH                  ; DX=000B
E138 B058                       MOV     AL,058H                 ; SET DMA MODE,CH 0,READ,AUTOINT
E13A EE                         OUT     DX,AL                   ; WRITE DMA MODE REG
E13B B000                       MOV     AL,0                    ; ENABLE DMA CONTROLLER
E13D E608                       OUT     DMA+8,AL                ; SETUP DMA COMMAND REG
E13F 50                         PUSH    AX
E140 E60A                       OUT     DMA+10,AL               ; ENABLE CHANNEL 0 FOR REFRESH
E142 B103                       MOV     CL,3
E144 B041                       MOV     AL,41H                  ; SET MODE FOR CHANNEL 1
E146                    C18A:
E146 EE                         OUT     DX,AL
E147 FEC0                       INC     AL                      ; POINT TO NEXT CHANNEL
E149 E2FB                       LOOP    C18A
                        ;------------------------------------------------------------
                        ;       BASE 16K READ/WRITE STORAGE TEST                    :
                        ; DESCRIPTION                                               :
                        ;       WRITE/READ/VERIFY DATA PATTERNS FF,55,AA,01, AND 00 :
                        ;       TO 1ST 16K OF STORAGE.  VERIFY STORAGE ADDRESSABILITY. :
                        ;       INITIALIZE THE 8259 INTERRUPT CONTROLLER CHIP FOR   :
                        ;       CHECKING MANUFACTURING TEST 2 MODE.                 :
                        ;------------------------------------------------------------

                        ;----- DETERMINE MEMORY SIZE AND FILL MEMORY WITH DATA

E14B BA1302                     MOV     DX,0213H                ; ENABLE EXPANSION BOX
E14E B001                       MOV     AL,01H
E150 EE                         OUT     DX,AL
E151 8B2E7204                   MOV     BP,DATA_WORD[OFFSET RESET_FLAG] ; SAVE 'RESET_FLAG' IN BP
E155 81FD3412                   CMP     BP,1234H                ; WARM START?
E159 740A                       JE      C18B                    ; BYPASS STG TST.
E15B BC41F090                   MOV     SP,OFFSET C2
E15F E9B6FE                     JMP     STGTST
E162                    C24:
E162 7401                       JE      C18B                    ; PROCEED IF STGTST OK
E164 F4                         HLT                             ; HALT IF NOT
E165                    C18B:
E165 2BFF                       SUB     DI,DI
E167 E460                       IN      AL,PORT_A               ; DETERMINE BASE RAM SIZE
E169 240C                       AND     AL,0CH                  ; ISOLATE RAM SIZE SWS
E16B 0404                       ADD     AL, 4                   ; CALCULATE MEMORY SIZE
E16D B10C                       MOV     CL, 12
```

```
LOC OBJ              SOURCE

E16F D3E0                      SHL    AX, CL
E171 8BC8                      MOV    CX, AX
E173 FC                        CLD                           ; SET DIR FLAG TO INCR
E174                   C19:
E174 AA                        STOSB                         ; FILL BASE RAM WITH DATA
E175 E2FD                      LOOP   C19                    ; LOOP TIL ALL ZERO
E177 892E7204                  MOV    DATA_WORD[OFFSET RESET_FLAG],BP

                       ;----- DETERMINE IO CHANNEL RAM SIZE

E17B B0F8                      MOV    AL,0F8H                ; ENABLE SWITCH 5
E17D E661                      OUT    PORT_B,AL
E17F E462                      IN     AL,PORT_C              ; READ SWITCHES
E181 2401                      AND    AL,00000001B           ; ISOLATE SWITCH 5
E183 B10C                      MOV    CL,12D
E185 D3C0                      ROL    AX,CL
E187 B0FC                      MOV    AL,0FCH                ; DISABLE SW. 5
E189 E661                      OUT    PORT_B,AL
E18B E462                      IN     AL,PORT_C
E18D 240F                      AND    AL,0FH
E18F 0AC4                      OR     AL,AH                  ; COMBINE SWITCH VALUES
E191 8AD8                      MOV    BL,AL                  ; SAVE
E193 B420                      MOV    AH,32
E195 F6E4                      MUL    AH                     ; CALC. LENGTH
E197 A31504                    MOV    DATA_WORD[OFFSET IO_RAM_SIZE],AX        ;SAVE IT
E19A 7418                      JZ     C21
E19C BA0010                    MOV    DX,1000H               ; SEGMENT FOR I/O RAM
E19F 8AE0                      MOV    AH,AL
E1A1 B000                      MOV    AL,0
E1A3                   C20:                                  ; FILL_IO:
E1A3 8EC2                      MOV    ES,DX
E1A5 B90080                    MOV    CX,8000H               ; FILL 32K BYTES
E1A8 2BFF                      SUB    DI,DI
E1AA F3                        REP    STOSB
E1AB AA
E1AC 81C20008                  ADD    DX,800H                ; NEXT SEGMENT VALUE
E1B0 FECB                      DEC    BL
E1B2 75EF                      JNZ    C20                    ; FILL_IO
                       ;-------------------------------------------------------------
                       ;       INITIALIZE THE 8259 INTERRUPT CONTROLLER CHIP         :
                       ;-------------------------------------------------------------
E1B4                   C21:
E1B4 B013                      MOV    AL,13H                 ; ICW1 - EDGE, SNGL, ICW4
E1B6 E620                      OUT    INTA00,AL
E1B8 B008                      MOV    AL,8                   ; SETUP ICW2 - INT TYPE 8 (8-F)
E1BA E621                      OUT    INTA01,AL
E1BC B009                      MOV    AL,9                   ; SETUP ICW4 - BUFFRD,8086 MODE
E1BE E621                      OUT    INTA01,AL
E1C0 2BC0                      SUB    AX,AX                  ; POINT ES TO BEGIN
E1C2 8EC0                      MOV    ES,AX                  ;  OF R/W STORAGE
                       ;----------------------------------------------------------------------------
                       ;       CHECK FOR MANUFACTURING TEST 2 TO LOAD TEST PROGRAMS FROM KEYBOARD.:
                       ;----------------------------------------------------------------------------

                       ;----- SETUP STACK SEG AND SP

E1C4 B83000                    MOV    AX,STACK               ; GET STACK VALUE
E1C7 8ED0                      MOV    SS,AX                  ; SET THE STACK UP
E1C9 BC0001                    MOV    SP,OFFSET TOS          ; STACK IS READY TO GO
E1CC 81FD3412                  CMP    BP,1234H               ; RESET_FLAG SET?
E1D0 7425                      JE     C25                    ; YES - SKIP MFG TEST
E1D2 2BFF                      SUB    DI,DI
E1D4 8EDF                      MOV    DS, DI
E1D6 BB2400                    MOV    BX, 24H
E1D9 C70747FF                  MOV    WORD PTR [BX],OFFSET D11 ; SET UP KB INTERRUPT
E1DD 43                        INC    BX
E1DE 43                        INC    BX
E1DF 8C0F                      MOV    [BX],CS
E1E1 E85F04                    CALL   KBD_RESET              ; READ IN KB RESET CODE TO BL
E1E4 80FB65                    CMP    BL,065H                ; IS THIS MANUFACTURING TEST 2?
E1E7 750E                      JNZ    C25                    ; JUMP IF NOT MAN. TEST
E1E9 B2FF                      MOV    DL,255                 ; READ IN TEST PROGRAM
E1EB                   C22:
E1EB E86204                    CALL   SP_TEST
E1EE 8AC3                      MOV    AL,BL
E1F0 AA                        STOSB
```

Section 5

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LOC OBJ                SOURCE

E1F1 FECA                      DEC     DL
E1F3 75F6                      JNZ     C22                      ; JUMP IF NOT DONE YET
E1F5 CD3E                      INT     3EH                      ; SET INTERRUPT TYPE 62 ADDRESS F8H
E1F7                   C25:
                       ;----- SET UP THE BIOS INTERRUPT VECTORS TO TEMP INTERRUPT
E1F7 B92000                    MOV     CX,32                    ; FILL ALL 32 INTERRUPTS
E1FA 2BFF                      SUB     DI,DI                    ; FIRST INTERRUPT LOCATOIN
E1FC                   D3:
E1FC B847FF                    MOV     AX,OFFSET D11            ; MOVE ADDR OF INTR PROC TO TBL
E1FF AB                        STOSW
E200 8CC8                      MOV     AX,CS                    ; GET ADDR OF INTR PROC SEG
E202 AB                        STOSW
E203 E2F7                      LOOP    D3                       ; VECTBLO
                       ;----- SET UP OTHER INTERRUPTS AS NECESSARY
E205 C7060800C3E2              MOV     NMI_PTR,OFFSET NMI_INT   ; NMI INTERRUPT
E20B C706140054FF              MOV     INT5_PTR,OFFSET PRINT_SCREEN    ; PRINT SCREEN
E211 C706620000F6              MOV     BASIC_PTR+2,0F600H       ; SEGMENT FOR CASSETTE BASIC
                       ;------------------------------------------------------------------
                       ;       8259 INTERRUPT CONTROLLER TEST                            :
                       ; DESCRIPTION                                                     :
                       ;       READ/WRITE THE INTERRUPT MASK REGISTER (IMR) WITH ALL    :
                       ;       ONES AND ZEROES. ENABLE SYSTEM INTERRUPTS.  MASK DEVICE :
                       ;       INTERRUPTS OFF. CHECK FOR HOT INTERRUPTS (UNEXPECTED).   :
                       ;------------------------------------------------------------------
                       ;----- TEST THE IMR REGISTER
E217 BA2100                    MOV     DX,0021H                 ; POINT INTR. CHIP ADDR 21
E21A B000                      MOV     AL,0                     ; SET IMR TO ZERO
E21C EE                        OUT     DX,AL
E21D EC                        IN      AL,DX                    ; READ IMR
E21E 0AC0                      OR      AL,AL                    ; IMR = 0?
E220 7515                      JNZ     D6                       ; GO TO ERR ROUTINE IF NOT 0
E222 B0FF                      MOV     AL,0FFH                  ; DISABLE DEVICE INTERRUPTS
E224 EE                        OUT     DX,AL                    ; WRITE TO IMR
E225 EC                        IN      AL,DX                    ; READ IMR
E226 0401                      ADD     AL,1                     ; ALL IMR BIT ON?
E228 750D                      JNZ     D6                       ; NO - GO TO ERR ROUTINE
                       ;----- CHECK FOR HOT INTERRUPTS
                       ;----- INTERRUPTS ARE MASKED OFF.  CHECK THAT NO INTERRUPTS OCCUR.
E22A 32E4                      XOR     AH,AH                    ; CLEAR AH REG
E22C FB                        STI                              ; ENABLE EXTERNAL INTERRUPTS
E22D 2BC9                      SUB     CX,CX                    ; WAIT 1 SEC FOR ANY INTRS THAT
E22F                   D4:
E22F E2FE                      LOOP    D4                       ;  MIGHT OCCUR
E231                   D5:
E231 E2FE                      LOOP    D5
E233 0AE4                      OR      AH,AH                    ; DID ANY INTERRUPTS OCCUR?
E235 7408                      JZ      D7                       ; NO - GO TO NEXT TEST
E237                   D6:
E237 BA0101                    MOV     DX,101H                  ; BEEP SPEAKER IF ERROR
E23A E89203                    CALL    ERR_BEEP                 ; GO TO BEEP SUBROUTINE
E23D FA                        CLI
E23E F4                        HLT                              ; HALT THE SYSTEM
                       ;----------------------------------------------
                       ;       8253 TIMER CHECKOUT                   :
                       ; DESCRIPTION                                 :
                       ;       VERIFY THAT THE SYSTEM TIMER (0)      :
                       ;       DOESN'T COUNT TOO FAST OR TOO SLOW.   :
                       ;----------------------------------------------
E23F                   D7:
E23F B0FE                      MOV     AL,0FEH                  ; MASK ALL INTRS EXCEPT LVL 0
E241 EE                        OUT     DX,AL                    ; WRITE THE 8259 IMR
E242 B010                      MOV     AL,00010000B             ; SEL TIM 0, LSB, MODE 0, BINARY
E244 E643                      OUT     TIM_CTL,AL               ; WRITE TIMER CONTROL MODE REG
E246 B91600                    MOV     CX,16H                   ; SET PGM LOOP CNT
E249 8AC1                      MOV     AL,CL                    ; SET TIMER 0 CNT REG
E24B E640                      OUT     TIMER0,AL                ; WRITE TIMER 0 CNT REG
```

```
LOC OBJ                LINE   SOURCE

E24D                          D8:
E24D F6C4FF                          TEST    AH,0FFH                 ; DID TIMER 0 INTERRUPT OCCUR?
E250 7504                            JNZ     D9                      ; YES - CHECK TIMER OP FOR SLOW TIME
E252 E2F9                            LOOP    D8                      ; WAIT FOR INTR FOR SPECIFIED TIME
E254 EBE1                            JMP     D6                      ; TIMER 0 INTR DIDN'T OCCUR - ERR
E256                          D9:
E256 B112                            MOV     CL,18                   ; SET PGM LOOP CNT
E258 B0FF                            MOV     AL,0FFH                 ; WRITE TIMER 0 CNT REG
E25A E640                            OUT     TIMER0,AL
E25C B8FE00                          MOV     AX,0FEH
E25F EE                              OUT     DX,AL
E260                          D10:
E260 F6C4FF                          TEST    AH,0FFH                 ; DID TIMER 0 INTERRUPT OCCUR?
E263 75D2                            JNZ     D6                      ; YES - TIMER CNTING TOO FAST, ERR
E265 E2F9                            LOOP    D10                     ; WAIT FOR INTR FOR SPECIFIED TIME

                              ;----- ESTABLISH BIOS SUBROUTINE CALL INTERRUPT VECTORS

E267 1E                              PUSH    DS                      ; SAVE POINTER TO DATA AREA
E268 BF4000                          MOV     DI,OFFSET VIDEO_INT     ; SETUP ADDR TO INTR AREA
E26B 0E                              PUSH    CS
E26C 1F                              POP     DS                      ; SETUP ADDR OF VECTOR TABLE
E26D BE03FF90                        MOV     SI,OFFSET VECTOR_TABLE+16       ; START WITH VIDEO ENTRY
E271 B91000                          MOV     CX,16

                              ;----- SETUP TIMER 0 TO MODE 3

E274 B0FF                            MOV     AL,0FFH                 ; DISABLE ALL DEVICE INTERRUPTS
E276 EE                              OUT     DX,AL
E277 B036                            MOV     AL,36H                  ; SEL TIM 0,LSB,MSB,MODE 3
E279 E643                            OUT     TIMER+3,AL              ; WRITE TIMER MODE REG
E27B B000                            MOV     AL,0
E27D E640                            OUT     TIMER,AL                ; WRITE LSB TO TIMER 0 REG
E27F                          E1A:
E27F A5                              MOVSW                           ; MOVE VECTOR TABLE TO RAM
E280 47                              INC     DI                      ; MOVE PAST SEGMENT POINTER
E281 47                              INC     DI
E282 E2FB                            LOOP    E1A
E284 E640                            OUT     TIMER,AL                ; WRITE MSB TO TIMER 0 REG
E286 1F                              POP     DS                      ; RECOVER DATA SEG POINTER

                              ;----- SETUP TIMER 0 TO BLINK LED IF MANUFACTURING TEST MODE

E287 E8B903                          CALL    KBD_RESET               ; SEND SOFTWARE RESET TO KEYBRD
E28A 80FBAA                          CMP     BL,0AAH                 ; SCAN CODE 'AA' RETURNED?
E28D 741E                            JE      E6                      ; YES - CONTINUE (NON MFG MODE)
E28F B03C                            MOV     AL,3CH                  ; EN KBD, SET KBD CLK LINE LOW
E291 E661                            OUT     PORT_B,AL               ; WRITE 8255 PORT B
E293 90                              NOP
E294 90                              NOP
E295 E460                            IN      AL,PORT_A               ; WAS A BIT CLOCKED IN?
E297 24FF                            AND     AL,0FFH
E299 750E                            JNZ     E2                      ; YES - CONTINUE (NON MFG MODE)
E29B FE061204                        INC     DATA_AREA[OFFSET MFG_TST]       ; ELSE SET SW FOR MFG TEST MODE
E29F C70620006DE6                    MOV     INT_ADDR,OFFSET BLINK_INT       ; SETUP TIMER INTR TO BLINK LED
E2A5 B0FE                            MOV     AL,0FEH                 ; ENABLE TIMER INTERRUPT
E2A7 E621                            OUT     INTA01,AL
E2A9                          E2:                                    ; JUMPER_NOT_IN:
E2A9 B0CC                            MOV     AL,0CCH                 ; RESET THE KEYBOARD
E2AB E661                            OUT     PORT_B,AL

                              ;--------------------------------------------------------
                              ;       INITIALIZE AND START CRT CONTROLLER (6845)      :
                              ;       TEST VIDEO READ/WRITE STORAGE.                 :
                              ; DESCRIPTION                                          :
                              ;       RESET THE VIDEO ENABLE SIGNAL.                 :
                              ;       SELECT ALPHANUMERIC MODE, 40 * 25, B & W.      :
                              ;       READ/WRITE DATA PATTERNS TO STG. CHECK STG     :
                              ;       ADDRESSABILITY.                                :
                              ;--------------------------------------------------------
E2AD                          E6:
E2AD E460                            IN      AL,PORT_A               ; READ SENSE SWITCHES
E2AF B400                            MOV     AH,0
E2B1 A31004                          MOV     DATA_WORD[OFFSET EQUIP_FLAG],AX ; STORE SENSE SW INFO
E2B4                          E6A:
E2B4 2430                            AND     AL,30H                  ; ISOLATE VIDEO SWS
E2B6 7529                            JNZ     E7                      ; VIDEO SWS SET TO 0?
```

```
LOC OBJ                    SOURCE

E2B8 C706400053FF                   MOV     VIDEO_INT,OFFSET DUMMY_RETURN
E2BE E9A200                         JMP     E18_1                     ; SKIP VIDEO TESTS FOR BURN-IN

E2C3                                ORG     0E2C3H
E2C3                        NMI_INT PROC    NEAR
E2C3 50                             PUSH    AX                        ; SAVE ORIG CONTENTS OF AX
E2C4 E462                           IN      AL,PORT_C
E2C6 A8C0                           TEST    AL,0C0H                   ; PARITY CHECK?
E2C8 7415                           JZ      D14                       ; NO, EXIT FROM ROUTINE
E2CA BEDAFF90                       MOV     SI,OFFSET D1              ; ADDR OF ERROR MSG
E2CE A840                           TEST    AL,40H                    ; I/O PARITY CHECK
E2D0 7504                           JNZ     D13                       ; DISPLAY ERROR MSG
E2D2 BE23FF90                       MOV     SI,OFFSET D2              ; MUST BE PLANAR
E2D6                        D13:
E2D6 2BC0                           SUB     AX,AX                     ; INIT AND SET MODE FOR VIDEO
E2D8 CD10                           INT     10H                       ; CALL VIDEO_IO PROCEDURE
E2DA E8DD03                         CALL    P_MSG                     ; PRINT ERROR MSG
E2DD FA                             CLI
E2DE F4                             HLT                               ; HALT SYSTEM
E2DF                        D14:
E2DF 58                             POP     AX                        ; RESTORE ORIG CONTENTS OF AX
E2E0 CF                             IRET
                            NMI_INT ENDP
E2E1                        E7:                                       ; TEST_VIDEO:
E2E1 3C30                           CMP     AL,30H                    ; B/W CARD ATTACHED?
E2E3 7408                           JE      E8                        ; YES - SET MODE FOR B/W CARD
E2E5 FEC4                           INC     AH                        ; SET COLOR MODE FOR COLOR CD
E2E7 3C20                           CMP     AL,20H                    ; 80X25 MODE SELECTED?
E2E9 7502                           JNE     E8                        ; NO - SET MODE FOR 40X25
E2EB B403                           MOV     AH,3                      ; SET MODE FOR 80X25
E2ED                        E8:
E2ED 86E0                           XCHG    AH,AL                     ; SET_MODE
E2EF 50                             PUSH    AX                        ; SAVE VIDEO MODE ON STACK
E2F0 2AE4                           SUB     AH,AH                     ; INITIALIZE TO ALPHANUMERIC MD
E2F2 CD10                           INT     10H                       ; CALL VIDEO_IO
E2F4 58                             POP     AX                        ; RESTORE VIDEO SENSE SWS IN AH
E2F5 50                             PUSH    AX                        ; RESAVE VALUE
E2F6 BB00B0                         MOV     BX,0B000H                 ; BEG VIDEO RAM ADDR B/W CD
E2F9 BAB803                         MOV     DX,3B8H                   ; MODE REG FOR B/W
E2FC B90010                         MOV     CX,4096                   ; RAM BYTE CNT FOR B/W CD
E2FF B001                           MOV     AL,1                      ; SET MODE FOR BW CARD
E301 80FC30                         CMP     AH,30H                    ; B/W VIDEO CARD ATTACHED?
E304 7408                           JE      E9                        ; YES - GO TEST VIDEO STG
E306 B7B8                           MOV     BH,0B8H                   ; BEG VIDEO RAM ADDR COLOR CD
E308 B2D8                           MOV     DL,0D8H                   ; MODE REG FOR COLOR CD
E30A B540                           MOV     CH,40H                    ; RAM BYTE CNT FOR COLOR CD
E30C FEC8                           DEC     AL                        ; SET MODE TO 0 FOR COLOR CD
E30E                        E9:                                       ; TEST_VIDEO_STG:
E30E EE                             OUT     DX,AL                     ; DISABLE VIDEO FOR COLOR CD
E30F 81FD3412                       CMP     BP,1234H                  ; POD INITIATED BY KBD RESET?
E313 8EC3                           MOV     ES,BX                     ; POINT ES TO VIDEO RAM STG
E315 7407                           JE      E10                       ; YES - SKIP VIDEO RAM TEST
E317 8EDB                           MOV     DS,BX                     ; POINT DS TO VIDEO RAM STG
                                    ASSUME  DS:NOTHING,ES:NOTHING
E319 E8FFFC                         CALL    STGTST_CNT                ; GO TEST VIDEO R/W STG
E31C 7532                           JNE     E17                       ; R/W STG FAILURE - BEEP SPK
                            ;-------------------------------------------------------------
                            ;       SETUP VIDEO DATA ON SCREEN FOR VIDEO LINE TEST.       :
                            ; DESCRIPTION                                                 :
                            ;       ENABLE VIDEO SIGNAL AND SET MODE.                     :
                            ;       DISPLAY A HORIZONTAL BAR ON SCREEN.                   :
                            ;-------------------------------------------------------------
E31E                        E10:
E31E 58                             POP     AX                        ; GET VIDEO SENSE SWS (AH)
E31F 50                             PUSH    AX                        ; SAVE IT
E320 B400                           MOV     AH,0                      ; ENABLE VIDEO AND SET MODE
E322 CD10                           INT     10H                       ; VIDEO
E324 B82070                         MOV     AX,7020H                  ; WRT BLANKS IN REVERSE VIDEO
E327 2BFF                           SUB     DI,DI                     ; SETUP STARTING LOC
E329 B92800                         MOV     CX,40                     ; NO. OF BLANKS TO DISPLAY
E32C F3                             REP     STOSW                     ; WRITE VIDEO STORAGE
E32D AB
                            ;-----------------------------------------------------
                            ;       CRT INTERFACE LINES TEST                     :
                            ; DESCRIPTION                                        :
                            ;       SENSE ON/OFF TRANSITION OF THE VIDEO ENABLE  :
```

```
LOC OBJ                 LINE    SOURCE

                                ;       AND HORIZONTAL SYNC LINES.                      :
                                ;-------------------------------------------------------
E32E 58                                 POP     AX                      ; GET VIDEO SENSE SW INFO
E32F 50                                 PUSH    AX                      ; SAVE IT
E330 80FC30                             CMP     AH,30H                  ; B/W CARD ATTACHED?
E333 BABA03                             MOV     DX,03BAH                ; SETUP ADDR OF BW STATUS PORT
E336 7402                               JE      E11                     ; YES - GO TEST LINES
E338 B2DA                               MOV     DL,0DAH                 ; COLOR CARD IS ATTACHED
E33A                            E11:                                    ; LINE_TST:
E33A B408                               MOV     AH,8
E33C                            E12:                                    ; OFLOOP_CNT:
E33C 2BC9                               SUB     CX,CX
E33E                            E13:
E33E EC                                 IN      AL,DX                   ; READ CRT STATUS PORT
E33F 22C4                               AND     AL,AH                   ; CHECK VIDEO/HORZ LINE
E341 7504                               JNZ     E14                     ; ITS ON - CHECK IF IT GOES OFF
E343 E2F9                               LOOP    E13                     ; LOOP TILL ON OR TIMEOUT
E345 EB09                               JMP     SHORT E17               ; GO PRINT ERROR MSG
E347                            E14:
E347 2BC9                               SUB     CX,CX
E349                            E15:
E349 EC                                 IN      AL,DX                   ; READ CRT STATUS PORT
E34A 22C4                               AND     AL,AH                   ; CHECK VIDEO/HORZ LINE
E34C 740A                               JZ      E16                     ; ITS ON - CHECK NEXT LINE
E34E E2F9                               LOOP    E15                     ; LOOP IF OFF TILL IT GOES ON
E350                            E17:                                    ;  CRT_ERR
E350 BA0201                             MOV     DX,102H
E353 E87902                             CALL    ERR_BEEP                ; GO BEEP SPEAKER
E356 EB06                               JMP     SHORT E18
E358                            E16:                                    ; NXT_LINE
E358 B103                               MOV     CL,3                    ; GET NEXT BIT TO CHECK
E35A D2EC                               SHR     AH,CL
E35C 75DE                               JNZ     E12                     ; GO CHECK HORIZONTAL LINE
E35E                            E18:                                    ;  DISPLAY_CURSOR:
E35E 58                                 POP     AX                      ; GET VIDEO SENSE SWS (AH)
E35F B400                               MOV     AH,0                    ; SET MODE AND DISPLAY CURSOR
E361 CD10                               INT     10H                     ; CALL VIDEO I/O PROCEDURE

E363                            E18_1:
E363 BA00C0                             MOV     DX,0C000H
E366                            E18A:
E366 8EDA                               MOV     DS,DX
E368 2BDB                               SUB     BX,BX
E36A 8B07                               MOV     AX,[BX]                 ; GET FIRST 2 LOCATIONS
E36C 53                                 PUSH    BX
E36D 5B                                 POP     BX                      ; LET BUS SETTLE
E36E 3D55AA                             CMP     AX,0AA55H               ; PRESENT?
E371 7505                               JNZ     E18B                    ; NO? GO LOOK FOR OTHER MODULES
E373 E80E03                             CALL    ROM_CHECK               ; GO SCAN MODULE
E376 EB04                               JMP     SHORT E18C
E378                            E18B:
E378 81C28000                           ADD     DX,0080H                ; POINT TO NEXT 2K BLOCK
E37C                            E18C:
E37C 81FA00C8                           CMP     DX,0C800H               ; TOP OF VIDEO ROM AREA YET?
E380 7CE4                               JL      E18A                    ; GO SCAN FOR ANOTHER MODULE
                                ;-----------------------------------------------------------------
                                ; EXPANSION I/O BOX TEST                                          :
                                ;       CHECK TO SEE IF EXPANSION BOX PRESENT - IF INSTALLED,     :
                                ;       TEST DATA AND ADDRESS BUSES TO I/O BOX.                   :
                                ; ERROR='1801'                                                    :
                                ;-----------------------------------------------------------------

                                ;----- DETERMINE IF BOX IS PRESENT

E382                            EXP_IO:                                 ; (CARD WAS ENABLED EARLIER)
E382 BA1002                             MOV     DX,0210H                ; CONTROL PORT ADDRESS
E385 B85555                             MOV     AX,5555H                ; SET DATA PATTERN
E388 EE                                 OUT     DX,AL
E389 B001                               MOV     AL,01H
E38B EC                                 IN      AL,DX                   ; RECOVER DATA
E38C 3AC4                               CMP     AL,AH                   ; REPLY?
E38E 7534                               JNE     E19                     ; NO RESPONSE, GO TO NEXT TEST
E390 F7D0                               NOT     AX                      ; MAKE DATA=AAAA
E392 EE                                 OUT     DX,AL
E393 B001                               MOV     AL,01H
E395 EC                                 IN      AL,DX                   ; RECOVER DATA
E396 3AC4                               CMP     AL,AH
```

Section 5

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LOC OBJ                 LINE    SOURCE

E398 752A                             JNE     E19                     ; NO ANSWER=NEXT TEST

                                ;----- CHECK ADDRESS AND DATA BUS

E39A                            EXP1:
E39A 8BD8                             MOV     BX,AX
E39C BA1402                           MOV     DX,0214H                ; LOAD DATA  REG ADDRESS
E39F 2E8807                           MOV     CS:[BX],AL              ; WRITE ADDRESS F0000+BX
E3A2 EE                               OUT     DX,AL                   ; WRITE DATA
E3A3 90                               NOP
E3A4 EC                               IN      AL,DX                   ; READ DATA
E3A5 3AC7                             CMP     AL,BH
E3A7 7514                             JNE     EXP_ERR
E3A9 42                               INC     DX                      ; DX=215H (ADDR. HI REG)
E3AA EC                               IN      AL,DX
E3AB 3AC4                             CMP     AL,AH                   ; COMPARE TO HI ADDRESS
E3AD 750E                             JNE     EXP_ERR
E3AF 42                               INC     DX                      ; DX-216H (ADDR. LOW REG)
E3B0 EC                               IN      AL,DX
E3B1 3AC4                             CMP     AL,AH                   ; ADDR. LOW OK?
E3B3 7508                             JNE     EXP_ERR
E3B5 F7D0                             NOT     AX                      ; INVERT AX
E3B7 3CAA                             CMP     AL,0AAH                 ; BACK TO STARTING VALUE (AAAA) YET
E3B9 7409                             JE      E19                     ; GO ON TO NEXT TEST IF SO
E3BB EBDD                             JMP     EXP1                    ; LOOP BACK THROUGH WITH DATA OF 5555
E3BD                            EXP_ERR:
E3BD BEEDFE90                         MOV     SI,OFFSET F3B
E3C1 E8F602                           CALL    P_MSG
                                ;---------------------------------------------------------------
                                ;       ADDITIONAL READ/WRITE STORAGE TEST                     :
                                ; DESCRIPTION                                                  :
                                ;       WRITE/READ DATA PATTERNS TO ANY READ/WRITE STORAGE     :
                                ;       AFTER THE BASIC 16K. STORAGE ADDRESSABILITY IS CHECKED. :
                                ;---------------------------------------------------------------
                                      ASSUME  DS:DATA
E3C4                            E19:

                                ;----- DETERMINE RAM SIZE ON PLANAR BOARD

E3C4 E8771B                           CALL    DDS
E3C7 A01000                           MOV     AL,BYTE PTR EQUIP_FLAG  ; GET SENSE SWS INFO
E3CA 240C                             AND     AL,0CH                  ; ISOLATE RAM SIZE SWS
E3CC B404                             MOV     AH,4
E3CE F6E4                             MUL     AH
E3D0 0410                             ADD     AL,16                   ; ADD BASIC 16K
E3D2 8BD0                             MOV     DX,AX                   ; SAVE PLANAR RAM SIZE IN DX
E3D4 8BD8                             MOV     BX,AX                   ;  AND IN BX

                                ;----- DETERMINE IO CHANNEL RAM SIZE

E3D6 A11500                           MOV     AX,IO_RAM_SIZE          ; GET IO CHANNEL RAM SIZE
E3D9 83FB40                           CMP     BX,40H                  ; PLANAR RAM SIZE = 64K?
E3DC 7402                             JE      E20                     ; YES - ADD IO CHN RAM SIZE
E3DE 2BC0                             SUB     AX,AX                   ; NO - DON'T ADD ANY IO RAM
E3E0                            E20:                                  ; ADD_IO_SIZE:
E3E0 03C3                             ADD     AX,BX                   ; SUM TOTAL RAM SIZE
E3E2 A31300                           MOV     MEMORY_SIZE,AX          ; SETUP MEMORY SIZE PARM
E3E5 81FD3412                         CMP     BP,1234H                ; POD INITIATED BY KBD RESET?
E3E9 1E                               PUSH    DS                      ; SAVE DATA SEGMENT
E3EA 744F                             JE      TST12                   ; YES - SKIP MEMORY TEST

                                ;----- TEST ANY OTHER READ/WRITE STORAGE AVAILABLE

E3EC BB0004                           MOV     BX,400H
E3EF B91000                           MOV     CX,16
E3F2                            E21:
E3F2 3BD1                             CMP     DX,CX                   ; ANY MORE STG TO BE TESTED?
E3F4 762D                             JBE     E23                     ; NO - GO TO NEXT TEST
E3F6 8EDB                             MOV     DS,BX                   ; SETUP STG ADDR IN DS AND ES
E3F8 8EC3                             MOV     ES,BX
E3FA 83C110                           ADD     CX,16                   ; INCREMENT STG BYTE COUNTER
E3FD 81C30004                         ADD     BX,400H                 ; SET POINTER TO NEXT 16K BLK
E401 51                               PUSH    CX                      ; SAVE REGS
E402 53                               PUSH    BX
E403 52                               PUSH    DX
E404 E811FC                           CALL    STGTST                  ; GO TEST A 16K BLK OF STG
E407 5A                               POP     DX
```

```
LOC OBJ                 SOURCE

E408 5B                         POP     BX                      ; RESTORE REGS
E409 59                         POP     CX
E40A 74E6                       JE      E21                     ; CHECK IF MORE STG TO TEST

                        ;----- PRINT FAILING ADDRESS AND XOR'ED PATTERN IF DATA COMPARE ERROR

E40C 8CDA                       MOV     DX,DS                   ; CONVERT FAILING HIGH-ORDER
E40E 8AE8                       MOV     CH,AL                   ; SAVE FAILING BIT PATTERN
E410 8AC6                       MOV     AL,DH                   ; GET FAILING ADDR
E412 E81002                     CALL    XPC_BYTE                ; CONVERT AND PRINT CODE
E415 8AC5                       MOV     AL,CH                   ; GET FAILING BIT PATTERN
E417 E80B02                     CALL    XPC_BYTE                ; CONVERT AND PRINT CODE
E41A BE67FA90                   MOV     SI,OFFSET E1            ; SETUP ADDRESS OF ERROR MSG
E41E E89902                     CALL    P_MSG                   ; PRINT ERROR MSG
E421                    E22:
E421 EB18                       JMP     SHORT TST12             ; GO TO NEXT TEST
E423                    E23:                                    ; STG_TEST_DONE
E423 1F                         POP     DS                      ; POINT DS TO DATA SEGMENT
E424 1E                         PUSH    DS
E425 8B161500                   MOV     DX,IO_RAM_SIZE          ; GET IO CHANNEL RAM SIZE
E429 0BD2                       OR      DX,DX                   ; SET FLAG RESULT
E42B 740E                       JZ      TST12                   ; NO IO RAM, GO TO NEXT TEST
E42D B90000                     MOV     CX,0
E430 81FB0010                   CMP     BX,1000H                ; HAS IO RAM BEEN TESTED
E434 7705                       JA      TST12                   ; YES - GO TO NEXT TEST
E436 BB0010                     MOV     BX,1000H                ; SETUP BEG LOC FOR IO RAM
E439 EBB7                       JMP     E21                     ; GO TEST IO CHANNEL RAM
                        ;-------------------------------------------------------
                        ;       KEYBOARD TEST                                  :
                        ; DESCRIPTION                                          :
                        ;       RESET THE KEYBOARD AND CHECK THAT SCAN CODE    :
                        ;       'AA' IS RETURNED TO THE CPU.  CHECK FOR STUCK  :
                        ;        KEYS.                                         :
                        ;-------------------------------------------------------
                                ASSUME  DS:DATA
E43B                    TST12:
E43B 1F                         POP     DS
E43C 803E120001                 CMP     MFG_TST,1               ; MANUFACTURING TEST MODE?
E441 742A                       JE      F7                      ; YES - SKIP KEYBOARD TEST
E443 E8FD01                     CALL    KBD_RESET               ; ISSUE SOFTWARE RESET TO KEYBRD
E446 E31E                       JCXZ    F6                      ; PRINT ERR MSG IF NO INTERRUPT
E448 B04D                       MOV     AL,4DH                  ; ENABLE KEYBOARD
E44A E661                       OUT     PORT_B,AL
E44C 80FBAA                     CMP     BL,0AAH                 ; SCAN CODE AS EXPECTED?
E44F 7515                       JNE     F6                      ; NO - DISPLAY ERROR MSG

                        ;----- CHECK FOR STUCK KEYS

E451 B0CC                       MOV     AL,0CCH                 ; CLR KBD, SET CLK LINE HIGH
E453 E661                       OUT     PORT_B,AL
E455 B04C                       MOV     AL,4CH                  ; ENABLE KBD,CLK IN NEXT BYTE
E457 E661                       OUT     PORT_B,AL
E459 2BC9                       SUB     CX,CX
E45B                    F5:                                     ; KBD_WAIT
E45B E2FE                       LOOP    F5                      ; DELAY FOR A WHILE
E45D E460                       IN      AL,KBD_IN               ; CHECK FOR STUCK KEYS
E45F 3C00                       CMP     AL,0                    ; SCAN CODE = 0?
E461 740A                       JE      F7                      ; YES - CONTINUE TESTING
E463 E8BF01                     CALL    XPC_BYTE                ; CONVERT AND PRINT
E466 BE33FF90           F6:     MOV     SI,OFFSET F1            ; GET MSG ADDR
E46A E84D02                     CALL    P_MSG                   ; PRINT MSG ON SCREEN

                        ;----- SETUP INTERRUPT VECTOR TABLE

E46D                    F7:                                     ; SETUP_INT_TABLE:
E46D 2BC0                       SUB     AX,AX
E46F 8EC0                       MOV     ES,AX
E471 B90800                     MOV     CX,8                    ; GET VECTOR CNT
E474 1E                         PUSH    DS                      ; SAVE DATA SEGMENT
E475 0E                         PUSH    CS                      ; SETUP DS SEG REG
E476 1F                         POP     DS
E477 BEF3FE90                   MOV     SI,OFFSET VECTOR_TABLE
E47B BF2000                     MOV     DI,OFFSET INT_PTR
E47E                    F7A:
E47E A5                         MOVSW
E47F 47                         INC     DI                      ; SKIP OVER SEGMENT
E480 47                         INC     DI
```

Section 5

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LOC OBJ          SOURCE

E481 E2FB               LOOP    F7A
                 ;-----------------------------------------------------
                 ;       CASSETTE DATA WRAP TEST                       :
                 ; DESCRIPTION                                         :
                 ;       TURN CASSETTE MOTOR OFF. WRITE A BIT OUT TO THE :
                 ;       CASSETTE DATA BUS. VERIFY THAT CASSETTE DATA  :
                 ;       READ IS WITHIN A VALID RANGE.                 :
                 ;-----------------------------------------------------

                 ;----- TURN THE CASSETTE MOTOR OFF

E483             TST13:
E483 1F                 POP     DS
E484 1E                 PUSH    DS
E485 B04D               MOV     AL,04DH                 ; SET TIMER 2 SPK OUT, AND CASST
E487 E661               OUT     PORT_B,AL               ; OUT BITS ON, CASSETTE MOT OFF

                 ;----- WRITE A BIT

E489 B0FF               MOV     AL,0FFH                 ; DISABLE TIMER INTERRUPTS
E48B E621               OUT     INTA01,AL
E48D B0B6               MOV     AL,0B6H                 ; SEL TIM 2, LSB, MSB, MD 3
E48F E643               OUT     TIMER+3,AL              ; WRITE 8253 CMD/MODE REG
E491 B8D304             MOV     AX,1235                 ; SET TIMER 2 CNT FOR 1000 USEC
E494 E642               OUT     TIMER+2,AL              ; WRITE TIMER 2 COUNTER REG
E496 8AC4               MOV     AL,AH                   ; WRITE MSB
E498 E642               OUT     TIMER+2,AL

                 ;----- READ CASSETTE INPUT

E49A E462               IN      AL,PORT_C               ; READ VALUE OF CASS IN BIT
E49C 2410               AND     AL,10H                  ; ISOLATE FROM OTHER BITS
E49E A26B00             MOV     LAST_VAL,AL
E4A1 E8D514             CALL    READ_HALF_BIT
E4A4 E8D214             CALL    READ_HALF_BIT
E4A7 E30C               JCXZ    F8                      ; CAS_ERR
E4A9 81FB4005           CMP     BX,MAX_PERIOD
E4AD 7306               JNC     F8                      ; CAS_ERR
E4AF 81FB1004           CMP     BX,MIN_PERIOD
E4B3 7307               JNC     ROM_SCAN                ; GO TO NEXT TEST IF OK
E4B5             F8:                                    ; CAS_ERR
E4B5 BE39FF90           MOV     SI,OFFSET F2            ; CASSETTE WRAP FAILED
E4B9 E8FE01             CALL    P_MSG                   ; GO PRINT ERROR MSG
                 ;--------------------------------------------------------------------
                 ;       CHECK FOR OPTIONAL ROM FROM C8000->F4000 IN 2K INCREMENTS   :
                 ;       (A VALID MODULE HAS '55AA' IN THE FIRST 2 LOCATIONS, LENGTH :
                 ;       INDICATOR (LENGTH/512) IN THE 3RD LOCATION AND TEST/INIT.   :
                 ;       CODE STARTING IN THE 4TH LOCATION.)                         :
                 ;--------------------------------------------------------------------
E4BC             ROM_SCAN:
E4BC BA00C8             MOV     DX,0C800H               ; SET BEGINNING ADDRESS
E4BF             ROM_SCAN_1:
E4BF 8EDA               MOV     DS,DX
E4C1 2BDB               SUB     BX,BX                   ; SET BX=0000
E4C3 8B07               MOV     AX,[BX]                 ; GET 1ST WORD FROM MODULE
E4C5 3D55AA             CMP     AX,0AA55H               ; = TO ID WORD?
E4C8 7505               JNZ     NEXT_ROM                ; PROCEED TO NEXT ROM IF NOT
E4CA E8B701             CALL    ROM_CHECK               ; GO DO CHECKSUM AND CALL
E4CD EB04               JMP     SHORT ARE_WE_DONE       ; CHECK FOR END OF ROM SPACE
E4CF             NEXT_ROM:
E4CF 81C28000           ADD     DX,0080H                ; POINT TO NEXT 2K ADDRESS
E4D3             ARE_WE_DONE:
E4D3 81FA00F6           CMP     DX,0F600H               ; AT F6000 YET?
E4D7 7CE6               JL      ROM_SCAN_1              ; GO CHECK ANOTHER ADD. IF NOT
E4D9 EB0190             JMP     BASE_ROM_CHK            ; GO CHECK BASIC ROM
                 ;-------------------------------------------
                 ;       ROS CHECKSUM II                    :
                 ; DESCRIPTION                              :
                 ;       A CHECKSUM IS DONE FOR THE 4 ROS   :
                 ;       MODULES CONTAINING BASIC CODE      :
                 ;-------------------------------------------
E4DC             BASE_ROM_CHK:
E4DC             E4:
E4DC 2BDB               SUB     BX,BX                   ; SETUP STARTING ROS ADDR
E4DE 8EDA               MOV     DS,DX
E4E0 E86907             CALL    ROS_CHECKSUM            ; CHECK ROS
```

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LOC OBJ                  SOURCE

E4E3 7403                        JE      E5                      ; CONTINUE IF OK
E4E5 E82103                      CALL    ROM_ERR                 ; POST ERROR
E4E8                     E5:
E4E8 80C602                      ADD     DH,02H                  ; POINT TO NEXT 8K MOCDULE
E4EB 80FEFE                      CMP     DH,0FEH
E4EE 75EC                        JNZ     E4                      ; YES - CONTINUE
E4F0 1F                          POP     DS                      ; RECOVER DATA SEG PTR
                         ;----------------------------------------------------------------
                         ;       DISKETTE ATTACHMENT TEST                                :
                         ; DESCRIPTION                                                   :
                         ;       CHECK IF IPL DISKETTE DRIVE IS ATTACHED TO SYSTEM. IF ATTACHED, :
                         ;       VERIFY STATUS OF NEC FDC AFTER A RESET. ISSUE A RECAL AND SEEK  :
                         ;       CMD TO FDC AND CHECK STATUS. COMPLETE SYSTEM INITIALIZATION     :
                         ;       THEN PASS CONTROL TO THE BOOT LOADER PROGRAM.                   :
                         ;----------------------------------------------------------------
E4F1                     F9:
E4F1 A01000                      MOV     AL,BYTE PTR EQUIP_FLAG  ; GET SENSE SWS INFO
E4F4 A801                        TEST    AL,01H                  ; IPL DISKETTE DRIVE ATTCH?
E4F6 750A                        JNZ     F10                     ; NO -SKIP THIS TEST
E4F8 803E120001                  CMP     MFG_TST,1               ; MANUFACTURING TEST MODE?
E4FD 753D                        JNE     F15A                    ; NO - GO TO BOOT LOADER
E4FF E959FB                      JMP     START                   ; YES - LOOP POWER-ON-DIAGS
E502                     F10:
E502 E421                        IN      AL,INTA01               ; DISK_TEST
E504 24BF                        AND     AL,0BFH                 ; ENABLE DISKETTE INTERRUPTS
E506 E621                        OUT     INTA01,AL
E508 B400                        MOV     AH,0                    ; RESET NEC FDC
E50A 8AD4                        MOV     DL,AH                   ; (POINT TO DISKETTE)
E50C CD13                        INT     13H                     ; VERIFY STATUS AFTER RESET
E50E 7221                        JC      F13

                         ;----- TURN DRIVE 0 MOTOR ON

E510 BAF203                      MOV     DX,03F2H                ; GET ADDR OF FDC CARD
E513 52                          PUSH    DX                      ; SAVE IT
E514 B01C                        MOV     AL,1CH                  ; TURN MOTOR ON, EN DMA/INT
E516 EE                          OUT     DX,AL                   ; WRITE FDC CONTROL REG
E517 2BC9                        SUB     CX,CX
E519                     F11:                                    ; MOTOR_WAIT:
E519 E2FE                        LOOP    F11                     ; WAIT FOR 1 SECOND
E51B                     F12:                                    ; MOTOR_WAIT1:
E51B E2FE                        LOOP    F12
E51D 33D2                        XOR     DX,DX                   ; SELECT DRIVE 0
E51F B501                        MOV     CH,1                    ; SELECT TRACK 1
E521 88163E00                    MOV     SEEK_STATUS,DL
E525 E85509                      CALL    SEEK                    ; RECALIBRATE DISKETTE
E528 7207                        JC      F13                     ; GO TO ERR SUBROUTINE IF ERR
E52A B522                        MOV     CH,34                   ; SELECT TRACK 34
E52C E84E09                      CALL    SEEK                    ; SEEK TO TRACK 34
E52F 7307                        JNC     F14                     ; OK, TURN MOTOR OFF
E531                     F13:                                    ; DSK_ERR:
E531 BEEAFF90                    MOV     SI,OFFSET F3            ; GET ADDR OF MSG
E535 E88201                      CALL    P_MSG                   ; GO PRINT ERROR MSG

                         ;----- TURN DRIVE 0 MOTOR OFF

E538                     F14:                                    ; DR0_OFF:
E538 B00C                        MOV     AL,0CH                  ; TURN DRIVE 0 MOTOR OFF
E53A 5A                          POP     DX                      ; RECOVER FDC CTL ADDRESS
E53B EE                          OUT     DX,AL

                         ;----- SETUP PRINTER AND RS232 BASE ADDRESSES IF DEVICE ATTACHED

E53C                     F15A:
E53C BE1E00                      MOV     SI,OFFSET KB_BUFFER
E53F 89361A00                    MOV     BUFFER_HEAD,SI          ; SETUP KEYBOARD PARAMETERS
E543 89361C00                    MOV     BUFFER_TAIL,SI
E547 89368000                    MOV     BUFFER_START,SI         ; DEFAULT TO STANDARD BUFFER
E54B 83C620                      ADD     SI,32                   ; (32 BYTES LONG)
E54E 89368200                    MOV     BUFFER_END,SI
E552 E421                        IN      AL,INTA01
E554 24FC                        AND     AL,0FCH                 ; ENABLE TIMER AND KBD INTS
E556 E621                        OUT     INTA01,AL
E558 BD3DE690                    MOV     BP,OFFSET F4            ; PRT_SRC_TBL
E55C 2BF6                        SUB     SI,SI
E55E                     F16:                                    ; PRT_BASE:
E55E 2E8B5600                    MOV     DX,CS:[BP]              ; GET PRINTER BASE ADDR
```

Section 5

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LOC OBJ                 SOURCE

E562 B0AA                       MOV     AL,0AAH                 ; WRITE DATA TO PORT A
E564 EE                         OUT     DX,AL
E565 52                         PUSH    DX
E566 EC                         IN      AL,DX                   ; READ PORT A
E567 5A                         POP     DX
E568 3CAA                       CMP     AL,0AAH                 ; DATA PATTERN SAME
E56A 7505                       JNE     F17                     ; NO - CHECK NEXT PRT CD
E56C 895408                     MOV     PRINTER_BASE[SI],DX     ; YES - STORE PRT BASE ADDR
E56F 46                         INC     SI                      ; INCREMENT TO NEXT WORD
E570 46                         INC     SI
E571                    F17:                                    ; NO_STORE:
E571 45                         INC     BP                      ; POINT TO NEXT BASE ADDR
E572 45                         INC     BP
E573 81FD43E6                   CMP     BP,OFFSET F4E           ; ALL POSSIBLE ADDRS CHECKED?
E577 75E5                       JNE     F16                     ; PRT_BASE
E579 2BDB                       SUB     BX,BX                   ; POINTER TO RS232 TABLE
E57B BAFA03                     MOV     DX,3FAH                 ; CHECK IF RS232 CD 1 ATTCH?
E57E EC                         IN      AL,DX                   ; READ INTR ID REG
E57F A8F8                       TEST    AL,0F8H
E581 7506                       JNZ     F18
E583 C707F803                   MOV     RS232_BASE[BX],3F8H     ; SETUP RS232 CD #1 ADDR
E587 43                         INC     BX
E588 43                         INC     BX
E589                    F18:
E589 B602                       MOV     DH,02H                  ; CHECK IF RS232 CD 2 ATTCH (AT 2FA)
E58B EC                         IN      AL,DX                   ; READ INTERRUPT ID REG
E58C A8F8                       TEST    AL,0F8H
E58E 7506                       JNZ     F19                     ; BASE_END
E590 C707F802                   MOV     RS232_BASE[BX],2F8H     ; SETUP RS232 CD #2
E594 43                         INC     BX
E595 43                         INC     BX

                        ;----- SET UP EQUIP FLAG TO INDICATE NUMBER OF PRINTERS AND RS232 CARDS

E596                    F19:                                    ; BASE_END:
E596 8BC6                       MOV     AX,SI                   ; SI HAS 2* NUMBER OF RS232
E598 B103                       MOV     CL,3                    ; SHIFT COUNT
E59A D2C8                       ROR     AL,CL                   ; ROTATE RIGHT 3 POSITIONS
E59C 0AC3                       OR      AL,BL                   ; OR IN THE PRINTER COUNT
E59E A21100                     MOV     BYTE PTR EQUIP_FLAG+1,AL ; STORE AS SECOND BYTE
E5A1 B201                       MOV     DL,01H                  ; DX=201
E5A3 EC                         IN      AL,DX
E5A4 A80F                       TEST    AL,0FH
E5A6 7505                       JNZ     F20                     ; NO_GAME_CARD
E5A8 800E110010                 OR      BYTE PTR EQUIP_FLAG+1,16
E5AD                    F20:

                        ;----- SET DEFAULT TIMEOUT VALUES FOR PRINTER AND RS232

E5AD 1E                         PUSH    DS
E5AE 07                         POP     ES
E5AF BF7800                     MOV     DI,OFFSET PRINT_TIM_OUT
E5B2 B81414                     MOV     AX,1414H                ; PRINTER DEFAULTS (COUNT=20)
E5B5 AB                         STOSW
E5B6 AB                         STOSW
E5B7 B80101                     MOV     AX,0101H                ; RS232 DEFAULTS=01
E5BA AB                         STOSW
E5BB AB                         STOSW

                        ;----- ENABLE NMI INTERRUPTS

E5BC B080                       MOV     AL,80H                  ; ENABLE NMI INTERRUPTS
E5BE E6A0                       OUT     0A0H,AL
E5C0 803E120001                 CMP     MFG_TST,1               ; MFG MODE?
E5C5 7406                       JE      F21                     ; LOAD_BOOT_STRAP
E5C7 BA0100                     MOV     DX,1
E5CA E80200                     CALL    ERR_BEEP                ; BEEP 1 SHORT TONE

E5CD                    F21:                                    ; LOAD_BOOT_STRAP:
E5CD CD19                       INT     19H                     ; BOOTSTRAP

                        ;-----------------------------------------------------
                        ;       INITIAL RELIABILITY TEST -- SUBROUTINES       :
                        ;-----------------------------------------------------
                                ASSUME  CS:CODE,DS:DATA
                        ;---------------------------------------------------------------------
                        ; SUBROUTINES FOR POWER ON DIAGNOSTICS                               :
```

```
LOC OBJ                SOURCE

                       ;       THIS PROCEDURE WILL ISSUE ONE LONG TONE (3 SECS) AND ONE OR     :
                       ;       MORE SHORT TONES (1 SEC) TO INDICATE A FAILURE ON THE PLANAR    :
                       ;       BOARD, A BAD RAM MODULE, OR A PROBLEM WITH THE CRT.             :
                       ; ENTRY PARAMETERS:                                                     :
                       ;       DH = NUMBER OF LONG TONES TO BEEP                               :
                       ;       DL = NUMBER OF SHORT TONES TO BEEP                              :
                       ;-----------------------------------------------------------------------
E5CF                   ERR_BEEP  PROC  NEAR
E5CF 9C                        PUSHF                          ; SAVE FLAGS
E5D0 FA                        CLI                            ; DISABLE SYSTEM INTERRUPTS
E5D1 1E                        PUSH    DS                     ; SAVE DS REG CONTENTS
E5D2 E86919                    CALL    DDS
E5D5 0AF6                      OR      DH,DH                  ; ANY LONG ONES TO BEEP
E5D7 7418                      JZ      G3                     ; NO, DO THE SHORT ONES
E5D9                   G1:                                    ; LONG_BEEP:
E5D9 B306                      MOV     BL,6                   ; COUNTER FOR BEEPS
E5DB E82500                    CALL    BEEP                   ; DO THE BEEP
E5DE E2FE              G2:     LOOP    G2                     ; DELAY BETWEEN BEEPS
E5E0 FECE                      DEC     DH                     ; ANY MORE TO DO
E5E2 75F5                      JNZ     G1                     ; DO IT
E5E4 803E120001                CMP     MFG_TST,1              ; MFG TEST MODE?
E5E9 7506                      JNE     G3                     ; YES - CONTINUE BEEPING SPEAKER
E5EB B0CD                      MOV     AL,0CDH                ; STOP BLINKING LED
E5ED E661                      OUT     PORT_B,AL
E5EF EBE8                      JMP     SHORT G1
E5F1                   G3:                                    ; SHORT_BEEP:
E5F1 B301                      MOV     BL,1                   ; COUNTER FOR A SHORT BEEP
E5F3 E80D00                    CALL    BEEP                   ; DO THE SOUND
E5F6                   G4:
E5F6 E2FE                      LOOP    G4                     ; DELAY BETWEEN BEEPS
E5F8 FECA                      DEC     DL                     ; DONE WITH SHORTS
E5FA 75F5                      JNZ     G3                     ; DO SOME MORE
E5FC                   G5:
E5FC E2FE                      LOOP    G5                     ; LONG DELAY BEFORE RETURN
E5FE                   G6:
E5FE E2FE                      LOOP    G6
E600 1F                        POP     DS                     ; RESTORE ORIG CONTENTS OF DS
E601 9D                        POPF                           ; RESTORE FLAGS TO ORIG SETTINGS
E602 C3                        RET                            ; RETURN TO CALLER
                       ERR_BEEP        ENDP

                       ;----- ROUTINE TO SOUND BEEPER

E603                   BEEP    PROC    NEAR
E603 B0B6                      MOV     AL,10110110B           ; SEL TIM 2,LSB,MSB,BINARY
E605 E643                      OUT     TIMER+3,AL             ; WRITE THE TIMER MODE REG
E607 B83305                    MOV     AX,533H                ; DIVISOR FOR 1000 HZ
E60A E642                      OUT     TIMER+2,AL             ; WRITE TIMER 2 CNT - LSB
E60C 8AC4                      MOV     AL,AH
E60E E642                      OUT     TIMER+2,AL             ; WRITE TIMER 2 CNT - MSB
E610 E461                      IN      AL,PORT_B              ; GET CURRENT SETTING OF PORT
E612 8AE0                      MOV     AH,AL                  ; SAVE THAT SETTING
E614 0C03                      OR      AL,03                  ; TURN SPEAKER ON
E616 E661                      OUT     PORT_B,AL
E618 2BC9                      SUB     CX,CX                  ; SET CNT TO WAIT 500 MS
E61A                   G7:
E61A E2FE                      LOOP    G7                     ; DELAY BEFORE TURNING OFF
E61C FECB                      DEC     BL                     ; DELAY CNT EXPIRED?
E61E 75FA                      JNZ     G7                     ; NO - CONTINUE BEEPING SPK
E620 8AC4                      MOV     AL,AH                  ; RECOVER VALUE OF PORT
E622 E661                      OUT     PORT_B,AL
E624 C3                        RET                            ; RETURN TO CALLER
                       BEEP    ENDP

                       ;----------------------------------------------
                       ; CONVERT AND PRINT ASCII CODE                 :
                       ;       AL MUST CONTAIN NUMBER TO BE CONVERTED. :
                       ;       AX AND BX DESTROYED.                   :
                       ;----------------------------------------------
E625                   XPC_BYTE        PROC    NEAR
E625 50                        PUSH    AX                     ; RESAVE FOR LOW NIBBLE DISPLAY
E626 B104                      MOV     CL,4                   ; SHIFT COUNT
E628 D2E8                      SHR     AL,CL                  ; NIBBLE SWAP
E62A E80300                    CALL    XLAT_PR                ; DO THE HIGH NIBBLE DISPLAY
E62D 58                        POP     AX                     ; RECOVER THE NIBBLE
E62E 240F                      AND     AL,0FH                 ; ISOLATE TO LOW NIBBLE
                                                              ; FALL INTO LOW NIBBLE CONVERSION
```

Section 5

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LOC OBJ          SOURCE

E630             XLAT_PR PROC    NEAR                    ; CONVERT 00-0F TO ASCII CHARACTER
E630 0490                ADD     AL,090H                 ; ADD FIRST CONVERSION FACTOR
E632 27                  DAA                             ; ADJUST FOR NUMERIC AND ALPHA RANGE
E633 1440                ADC     AL,040H                 ; ADD CONVERSION AND ADJUST LOW NIBBLE
E635 27                  DAA                             ; ADJUST HI NIBBLE TO ASCII RANGE
E636             PRT_HEX PROC    NEAR
E636 B40E                MOV     AH,14                   ; DISPLAY CHAR. IN AL
E638 B700                MOV     BH,0
E63A CD10                INT     10H                     ; CALL VIDEO_IO
E63C C3                  RET
                 PRT_HEX ENDP
                 XLAT_PR ENDP
                 XPC_BYTE        ENDP

E63D             F4      LABEL   WORD                    ; PRINTER SOURCE TABLE
E63D BC03                DW      3BCH
E63F 7803                DW      378H
E641 7802                DW      278H
E643             F4E     LABEL   WORD

                 ;-------------------------------------------------------------------
                 ;       THIS PROCEDURE WILL SEND A SOFTWARE RESET TO THE KEYBOARD.      :
                 ;       SCAN CODE 'AA' SHOULD BE RETURNED TO THE CPU.                   :
                 ;-------------------------------------------------------------------
E643             KBD_RESET       PROC    NEAR
E643 B00C                MOV     AL,0CH                  ; SET KBD CLK LINE LOW
E645 E661                OUT     PORT_B,AL               ; WRITE 8255 PORT B
E647 B95629              MOV     CX,10582                ; HOLD KBD CLK LOW FOR 20 MS
E64A             G8:
E64A E2FE                LOOP    G8                      ; LOOP FOR 20 MS
E64C B0CC                MOV     AL,0CCH                 ; SET CLK, ENABLE LINES HIGH
E64E E661                OUT     PORT_B,AL
E650             SP_TEST:                                ; ENTRY FOR MANUFACTURING TEST 2
E650 B04C                MOV     AL,4CH                  ; SET KBD CLK HIGH, ENABLE LOW
E652 E661                OUT     PORT_B,AL
E654 B0FD                MOV     AL,0FDH                 ; ENABLE KEYBOARD INTERRUPTS
E656 E621                OUT     INTA01,AL               ; WRITE 8259 IMR
E658 FB                  STI                             ; ENABLE SYSTEM INTERRUPTS
E659 B400                MOV     AH,0                    ; RESET INTERRUPT INDICATOR
E65B 2BC9                SUB     CX,CX                   ; SETUP INTERRUPT TIMEOUT CNT
E65D             G9:
E65D F6C4FF              TEST    AH,0FFH                 ; DID A KEYBOARD INTR OCCUR?
E660 7502                JNZ     G10                     ; YES - READ SCAN CODE RETURNED
E662 E2F9                LOOP    G9                      ; NO - LOOP TILL TIMEOUT
E664             G10:
E664 E460                IN      AL,PORT_A               ; READ KEYBOARD SCAN CODE
E666 8AD8                MOV     BL,AL                   ; SAVE SCAN CODE JUST READ
E668 B0CC                MOV     AL,0CCH                 ; CLEAR KEYBOARD
E66A E661                OUT     PORT_B,AL
E66C C3                  RET                             ; RETURN TO CALLER
                 KBD_RESET       ENDP

                 ;-------------------------------------------------------------------
                 ;       BLINK LED PROCEDURE FOR MFG BURN-IN AND RUN-IN TESTS            :
                 ;       IF LED IS ON, TURN IT OFF. IF OFF, TURN ON.                     :
                 ;-------------------------------------------------------------------
E66D             BLINK_INT       PROC    NEAR
E66D FB                  STI
E66E 50                  PUSH    AX                      ; SAVE AX REG CONTENTS
E66F E461                IN      AL,PORT_B               ; READ CURRENT VAL OF PORT B
E671 8AE0                MOV     AH,AL
E673 F6D0                NOT     AL                      ; FLIP ALL BITS
E675 2440                AND     AL,01000000B            ; ISOLATE CONTROL BIT
E677 80E4BF              AND     AH,10111111B            ; MASK OUT OF ORIGINAL VAL
E67A 0AC4                OR      AL,AH                   ; OR NEW CONTROL BIT IN
E67C E661                OUT     PORT_B,AL
E67E B020                MOV     AL,EOI
E680 E620                OUT     INTA00,AL
E682 58                  POP     AX                      ; RESTORE AX REG
E683 CF                  IRET
                 BLINK_INT       ENDP

                 ;----- CHECKSUM AND CALL INIT CODE IN OPTIONAL ROMS

E684             ROM_CHECK       PROC    NEAR
E684 B84000              MOV     AX,DATA                 ; SET ES=DATA
E687 8EC0                MOV     ES,AX
```

```
LOC OBJ                       SOURCE

E689 2AE4                             SUB     AH,AH                   ; ZERO OUT AH
E68B 8A4702                           MOV     AL,[BX+2]               ; GET LENGTH INDICATOR
E68E B109                             MOV     CL,09H                  ; MULTIPLY BY 512
E690 D3E0                             SHL     AX,CL
E692 8BC8                             MOV     CX,AX                   ; SET COUNT
E694 51                               PUSH    CX
E695 B104                             MOV     CL,4
E697 D3E8                             SHR     AX,CL
E699 03D0                             ADD     DX,AX                   ; SET POINTER TO NEXT MODULE
E69B 59                               POP     CX

E69C E8B005                           CALL    ROS_CHECKSUM_CNT        ; DO CHECKSUM
E69F 7405                             JZ      ROM_CHECK_1
E6A1 E86501                           CALL    ROM_ERR                 ; PRINT ERROR INFO
E6A4 EB13                             JMP     SHORT ROM_CHECK_END
E6A6                          ROM_CHECK_1:
E6A6 52                               PUSH    DX                      ; SAVE POINTER
E6A7 26C70600010300                   MOV     ES:IO_ROM_INIT,0003H    ; LOAD OFFSET
E6AE 268C1E0201                       MOV     ES:IO_ROM_SEG,DS        ; LOAD SEGMENT
E6B3 26FF1E0001                       CALL    DWORD PTR ES:IO_ROM_INIT        ; CALL INIT RTN.
E6B8 5A                               POP     DX
E6B9                          ROM_CHECK_END:
E6B9 C3                               RET
                              ROM_CHECK       ENDP

                              ;----------------------------------------------------
                              ; THIS SUBROUTINE WILL PRINT A MESSAGE ON THE DISPLAY   :
                              ;                                                      :
                              ; ENTRY REQUIREMENTS:                                  :
                              ;       SI = OFFSET(ADDRESS) OF MESSAGE BUFFER         :
                              ;       CX = MESSAGE BYTE COUNT                        :
                              ;       MAXIMUM MESSAGE LENGTH IS 36 CHARACTERS        :
                              ;----------------------------------------------------
E6BA                          P_MSG   PROC    NEAR
E6BA E88118                           CALL    DDS
E6BD 803E120001                       CMP     MFG_TST,1               ; MFG TEST MODE?
E6C2 7505                             JNE     G12                     ; NO - DISPLAY ERROR MSG
E6C4 B601                             MOV     DH,1                    ; YES - SETUP TO BEEP SPEAKER
E6C6 E906FF                           JMP     ERR_BEEP                ; YES - BEEP SPEAKER
E6C9                          G12:                                    ; WRITE_MSG:
E6C9 2E8A04                           MOV     AL,CS:[SI]              ; PUT CHAR IN AL
E6CC 46                               INC     SI                      ; POINT TO NEXT CHAR
E6CD 50                               PUSH    AX                      ; SAVE PRINT CHAR
E6CE E865FF                           CALL    PRT_HEX                 ; CALL VIDEO_IO
E6D1 58                               POP     AX                      ; RECOVER PRINT CHAR
E6D2 3C0A                             CMP     AL,10                   ; WAS IT LINE FEED
E6D4 75F3                             JNE     G12                     ; NO,KEEP PRINTING STRING
E6D6 C3                               RET
                              P_MSG   ENDP

E6D7 20524F4D                 F3A     DB      ' ROM',13,10
E6DB 0D
E6DC 0A

E6DD                          D_EOI   PROC    NEAR
E6DD 50                               PUSH    AX
E6DE B020                             MOV     AL,20H
E6E0 E620                             OUT     20H,AL
E6E2 58                               POP     AX
E6E3 CF                               IRET
                              D_EOI   ENDP

                              ;--- INT 19 ----------------------------------------------------
                              ; BOOT STRAP LOADER                                            :
                              ;       IF A 5 1/4" DISKETTE DRIVE IS AVAILABLE ON THE SYSTEM,  :
                              ;       TRACK 0, SECTOR 1 IS READ INTO THE BOOT LOCATION       :
                              ;       (SEGMENT 0, OFFSET 7C00) AND CONTROL IS TRANSFERRED    :
                              ;       THERE.                                                 :
                              ;                                                              :
                              ;       IF THERE IS NO DISKETTE DRIVE, OR IF THERE IS A        :
                              ;       HARDWARE ERROR CONTROL IS TRANSFERRED TO THE RESIDENT  :
                              ;       BASIC ENTRY POINT.                                     :
                              ;                                                              :
                              ; IPL ASSUMPTIONS:                                             :
                              ;       8255 PORT 60H BIT 0 = 1 IF IPL FROM DISKETTE           :
                              ;--------------------------------------------------------------
                                      ASSUME  CS:CODE,DS:ABS0
```

Section 5

```
LOC OBJ                 SOURCE

                        ;----- IPL WAS SUCCESSFUL

E6E4                    H4:
E6E4 EA007C0000                 JMP     BOOT_LOCN
E6F2                            ORG     0E6F2H
E6F2                    BOOT_STRAP      PROC    NEAR
E6F2 FB                         STI                             ; ENABLE INTERRUPTS
E6F3 2BC0                       SUB     AX,AX
E6F5 8ED8                       MOV     DS,AX

                        ;----- RESET DISKETTE PARAMETER TABLE VECTOR

E6F7 C7067800C7EF               MOV     WORD PTR DISK_POINTER,OFFSET DISK_BASE
E6FD 8C0E7A00                   MOV     WORD PTR DISK_POINTER+2,CS
E701 A11004                     MOV     AX,DATA_WORD[OFFSET EQUIP_FLAG] ; GET THE EQUIPMENT SWITCHES
E704 A801                       TEST    AL,1                    ; ISOLATE IPL SENSE SWITCH
E706 741E                       JZ      H3                      ; GO TO CASSETTE BASIC ENTRY POINT

                        ;----- MUST LOAD SYSTEM FROM DISKETTE -- CX HAS RETRY COUNT

E708 B90400                     MOV     CX,4                    ; SET RETRY COUNT
E70B                    H1:                                     ; IPL_SYSTEM
E70B 51                         PUSH    CX                      ; SAVE RETRY COUNT
E70C B400                       MOV     AH,0                    ; RESET THE DISKETTE SYSTEM
E70E CD13                       INT     13H                     ; DISKETTE_IO
E710 720F                       JC      H2                      ; IF ERROR, TRY AGAIN
E712 B80102                     MOV     AX,201H                 ; READ IN THE SINGLE SECTOR
E715 2BD2                       SUB     DX,DX
E717 8EC2                       MOV     ES,DX
E719 BB007C                     MOV     BX,OFFSET BOOT_LOCN
E71C B90100                     MOV     CX,1                    ; SECTOR 1, TRACK 0
E71F CD13                       INT     13H                     ; DISKETTE_IO
E721 59                 H2:     POP     CX                      ; RECOVER RETRY COUNT
E722 73C0                       JNC     H4                      ; CF SET BY UNSUCCESSFUL READ
E724 E2E5                       LOOP    H1                      ; DO IT FOR RETRY TIMES

                        ;----- UNABLE TO IPL FROM THE DISKETTE

E726                    H3:                                     ; CASSETTE_JUMP:
E726 CD18                       INT     18H                     ; USE INTERRUPT VECTOR TO GET TO BASIC
                        BOOT_STRAP      ENDP

                        ;-----INT 14---------------------------------------------------------
                        ; RS232_IO                                                          :
                        ;       THIS ROUTINE PROVIDES BYTE STREAM I/O TO THE COMMUNICATIONS   :
                        ;       PORT ACCORDING TO THE PARAMETERS:                              :
                        ;       (AH)=0  INITIALIZE THE COMMUNICATIONS PORT                     :
                        ;               (AL) HAS PARAMETERS FOR INITIALIZATION                 :
                        ;                                                                      :
                        ;       7       6       5       4       3       2       1       0      :
                        ;       ----- BAUD RATE --      -PARITY--     STOPBIT   --WORD LENGTH-- :
                        ;       000 - 110               X0 - NONE       0 - 1    10 - 7 BITS   :
                        ;       001 - 150               01 - ODD        1 - 2    11 - 8 BITS   :
                        ;       010 - 300               11 - EVEN                              :
                        ;       011 - 600                                                      :
                        ;       100 - 1200                                                     :
                        ;       101 - 2400                                                     :
                        ;       110 - 4800                                                     :
                        ;       111 - 9600                                                     :
                        ;                                                                      :
                        ;       ON RETURN, CONDITIONS SET AS IN CALL TO COMMO STATUS (AH=3)   :
                        ;       (AH)=1  SEND THE CHARACTER IN (AL) OVER THE COMMO LINE        :
                        ;               (AL) REGISTER IS PRESERVED                             :
                        ;               ON EXIT, BIT 7 OF AH IS SET IF THE ROUTINE WAS UNABLE  :
                        ;                       TO TRANSMIT THE BYTE OF DATA OVER THE LINE.    :
                        ;                       IF BIT 7 OF AH IS NOT SET, THE REMAINDER OF AH :
                        ;                       IS SET AS IN A STATUS REQUEST, REFLECTING THE  :
                        ;                       CURRENT STATUS OF THE LINE.                    :
                        ;       (AH)=2  RECEIVE A CHARACTER IN (AL) FROM COMMO LINE BEFORE    :
                        ;                       RETURNING TO CALLER                            :
                        ;               ON EXIT, AH HAS THE CURRENT LINE STATUS, AS SET BY THE :
                        ;                       THE STATUS ROUTINE, EXCEPT THAT THE ONLY BITS  :
                        ;                       LEFT ON ARE THE ERROR BITS (7,4,3,2,1)         :
                        ;                       IF AH HAS BIT 7 ON (TIME OUT) THE REMAINING    :
                        ;                       BITS ARE NOT PREDICTABLE.                      :
                        ;                       THUS, AH IS NON ZERO ONLY WHEN AN ERROR        :
```

```
LOC OBJ              LINE      SOURCE

                               ;                          OCCURRED.                                       :
                               ;          (AH)=3  RETURN THE COMMO PORT STATUS IN (AX)                   :
                               ;                  AH CONTAINS THE LINE STATUS                            :
                               ;                  BIT 7 = TIME OUT                                       :
                               ;                  BIT 6 = TRANS SHIFT REGISTER EMPTY                     :
                               ;                  BIT 5 = TRAN HOLDING REGISTER EMPTY                    :
                               ;                  BIT 4 = BREAK DETECT                                   :
                               ;                  BIT 3 = FRAMING ERROR                                  :
                               ;                  BIT 2 = PARITY ERROR                                   :
                               ;                  BIT 1 = OVERRUN ERROR                                  :
                               ;                  BIT 0 = DATA READY                                     :
                               ;                  AL CONTAINS THE MODEM STATUS                           :
                               ;                  BIT 7 = RECEIVED LINE SIGNAL DETECT                    :
                               ;                  BIT 6 = RING INDICATOR                                 :
                               ;                  BIT 5 = DATA SET READY                                 :
                               ;                  BIT 4 = CLEAR TO SEND                                  :
                               ;                  BIT 3 = DELTA RECEIVE LINE SIGNAL DETECT               :
                               ;                  BIT 2 = TRAILING EDGE RING DETECTOR                    :
                               ;                  BIT 1 = DELTA DATA SET READY                           :
                               ;                  BIT 0 = DELTA CLEAR TO SEND                            :
                               ;                                                                          :
                               ;          (DX) = PARAMETER INDICATING WHICH RS232 CARD (0,1 ALLOWED)     :
                               ;                                                                          :
                               ; DATA AREA RS232_BASE CONTAINS THE BASE ADDRESS OF THE 8250 ON THE       :
                               ;          CARD LOCATION 400H CONTAINS UP TO 4 RS232 ADDRESSES POSSIBLE   :
                               ;          DATA AREA LABEL RS232_TIM_OUT (BYTE) CONTAINS OUTER LOOP COUNT :
                               ;          VALUE FOR TIMEOUT (DEFAULT=1)                                  :
                               ; OUTPUT                                                                   :
                               ;          AX MODIFIED ACCORDING TO PARMS OF CALL                         :
                               ;          ALL OTHERS UNCHANGED                                           :
                               ;---------------------------------------------------------------------------
                                          ASSUME  CS:CODE,DS:DATA
E729                                      ORG     0E729H
E729                           A1         LABEL   WORD                  ; TABLE OF INIT VALUE
E729 1704                                 DW      1047                  ; 110 BAUD
E72B 0003                                 DW      768                   ; 150
E72D 8001                                 DW      384                   ; 300
E72F C000                                 DW      192                   ; 600
E731 6000                                 DW      96                    ; 1200
E733 3000                                 DW      48                    ; 2400
E735 1800                                 DW      24                    ; 4800
E737 0C00                                 DW      12                    ; 9600

E739                           RS232_IO           PROC    FAR

                               ;----- VECTOR TO APPROPRIATE ROUTINE

E739 FB                                   STI                           ; INTERRUPTS BACK ON
E73A 1E                                   PUSH    DS                    ; SAVE SEGMENT
E73B 52                                   PUSH    DX
E73C 56                                   PUSH    SI
E73D 57                                   PUSH    DI
E73E 51                                   PUSH    CX
E73F 53                                   PUSH    BX
E740 8BF2                                 MOV     SI,DX                 ; RS232 VALUE TO SI
E742 8BFA                                 MOV     DI,DX
E744 D1E6                                 SHL     SI,1                  ; WORD OFFSET
E746 E8F517                               CALL    DDS
E749 8B14                                 MOV     DX,RS232_BASE[SI]     ; GET BASE ADDRESS
E74B 0BD2                                 OR      DX,DX                 ; TEST FOR 0 BASE ADDRESS
E74D 7413                                 JZ      A3                    ; RETURN
E74F 0AE4                                 OR      AH,AH                 ; TEST FOR (AH)=0
E751 7416                                 JZ      A4                    ; COMMUN INIT
E753 FECC                                 DEC     AH                    ; TEST FOR (AH)=1
E755 7445                                 JZ      A5                    ; SEND AL
E757 FECC                                 DEC     AH                    ; TEST FOR (AH)=2
E759 746A                                 JZ      A12                   ; RECEIVE INTO AL
E75B                           A2:
E75B FECC                                 DEC     AH                    ; TEST FOR (AH)=3
E75D 7503                                 JNZ     A3
E75F E98300                               JMP     A18                   ; COMMUNICATION STATUS
E762                           A3:                                      ; RETURN FROM RS232
E762 5B                                   POP     BX
E763 59                                   POP     CX
E764 5F                                   POP     DI
E765 5E                                   POP     SI
E766 5A                                   POP     DX
```

Section 5

```
E767 1F              POP     DS
E768 CF              IRET                           ; RETURN TO CALLER, NO ACTION

              ;----- INITIALIZE THE COMMUNICATIONS PORT

E769          A4:
E769 8AE0            MOV     AH,AL                  ; SAVE INIT PARMS IN AH
E76B 83C203          ADD     DX,3                   ; POINT TO 8250 CONTROL REGISTER
E76E B080            MOV     AL,80H
E770 EE              OUT     DX,AL                  ; SET DLAB=1

              ;----- DETERMINE BAUD RATE DIVISOR

E771 8AD4            MOV     DL,AH                  ; GET PARMS TO DL
E773 B104            MOV     CL,4
E775 D2C2            ROL     DL,CL
E777 81E20E00        AND     DX,0EH                 ; ISOLATE THEM
E77B BF29E7          MOV     DI,OFFSET A1           ; BASE OF TABLE
E77E 03FA            ADD     DI,DX                  ; PUT INTO INDEX REGISTER
E780 8B14            MOV     DX,RS232_BASE[SI]      ; POINT TO HIGH ORDER OF DIVISOR
E782 42              INC     DX
E783 2E8A4501        MOV     AL,CS:[DI]+1           ; GET HIGH ORDER OF DIVISOR
E787 EE              OUT     DX,AL                  ; SET MS OF DIV TO 0
E788 4A              DEC     DX
E789 2E8A05          MOV     AL,CS:[DI]             ; GET LOW ORDER OF DIVISOR
E78C EE              OUT     DX,AL                  ; SET LOW OF DIVISOR
E78D 83C203          ADD     DX,3
E790 8AC4            MOV     AL,AH                  ; GET PARMS BACK
E792 241F            AND     AL,01FH                ; STRIP OFF THE BAUD BITS
E794 EE              OUT     DX,AL                  ; LINE CONTROL TO 8 BITS
E795 4A              DEC     DX
E796 4A              DEC     DX
E797 B000            MOV     AL,0
E799 EE              OUT     DX,AL                  ; INTERRUPT ENABLES ALL OFF
E79A EB49            JMP     SHORT A18              ; COM_STATUS

              ;----- SEND CHARACTER IN (AL) OVER COMMO LINE

E79C          A5:
E79C 50              PUSH    AX                     ; SAVE CHAR TO SEND
E79D 83C204          ADD     DX,4                   ; MODEM CONTROL REGISTER
E7A0 B003            MOV     AL,3                   ; DTR AND RTS
E7A2 EE              OUT     DX,AL                  ; DATA TERMINAL READY, REQUEST TO SEND
E7A3 42              INC     DX                     ; MODEM STATUS REGISTER
E7A4 42              INC     DX
E7A5 B730            MOV     BH,30H                 ; DATA SET READY & CLEAR TO SEND
E7A7 E84800          CALL    WAIT_FOR_STATUS        ; ARE BOTH TRUE
E7AA 7408            JE      A9                     ; YES, READY TO TRANSMIT CHAR
E7AC          A7:
E7AC 59              POP     CX
E7AD 8AC1            MOV     AL,CL                  ; RELOAD DATA BYTE
E7AF          A8:
E7AF 80CC80          OR      AH,80H                 ; INDICATE TIME OUT
E7B2 EBAE            JMP     A3                     ; RETURN
E7B4          A9:                                   ; CLEAR_TO_SEND
E7B4 4A              DEC     DX                     ; LINE STATUS REGISTER
E7B5          A10:                                  ; WAIT_SEND
E7B5 B720            MOV     BH,20H                 ; IS TRANSMITTER READY
E7B7 E83800          CALL    WAIT_FOR_STATUS        ; TEST FOR TRANSMITTER READY
E7BA 75F0            JNZ     A7                     ; RETURN WITH TIME OUT SET
E7BC          A11:                                  ; OUT_CHAR
E7BC 83EA05          SUB     DX,5                   ; DATA PORT
E7BF 59              POP     CX                     ; RECOVER IN CX TEMPORARILY
E7C0 8AC1            MOV     AL,CL                  ; MOVE CHAR TO AL FOR OUT, STATUS IN AH
E7C2 EE              OUT     DX,AL                  ; OUTPUT CHARACTER
E7C3 EB9D            JMP     A3                     ; RETURN

              ;----- RECEIVE CHARACTER FROM COMMO LINE

E7C5          A12:
E7C5 83C204          ADD     DX,4                   ; MODEM CONTROL REGISTER
E7C8 B001            MOV     AL,1                   ; DATA TERMINAL READY
E7CA EE              OUT     DX,AL
E7CB 42              INC     DX                     ; MODEM STATUS REGISTER
E7CC 42              INC     DX
E7CD          A13:                                  ; WAIT_DSR
E7CD B720            MOV     BH,20H                 ; DATA SET READY
```

```
LOC OBJ              SOURCE

E7CF E82000                  CALL    WAIT_FOR_STATUS         ; TEST FOR DSR
E7D2 75DB                    JNZ     A8                      ; RETURN WITH ERROR
E7D4                 A15:                                    ; WAIT_DSR_END
E7D4 4A                      DEC     DX                      ; LINE STATUS REGISTER
E7D5                 A16:                                    ; WAIT_RECV
E7D5 B701                    MOV     BH,1                    ; RECEIVE BUFFER FULL
E7D7 E81800                  CALL    WAIT_FOR_STATUS         ; TEST FOR REC. BUFF. FULL
E7DA 75D3                    JNZ     A8                      ; SET TIME OUT ERROR
E7DC                 A17:                                    ; GET_CHAR
E7DC 80E41E                  AND     AH,00011110B            ; TEST FOR ERR CONDITIONS ON RECV CHAR
E7DF 8B14                    MOV     DX,RS232_BASE[SI]       ; DATA PORT
E7E1 EC                      IN      AL,DX                   ; GET CHARACTER FROM LINE
E7E2 E97DFF                  JMP     A3                      ; RETURN

                     ;----- COMMO PORT STATUS ROUTINE

E7E5                 A18:
E7E5 8B14                    MOV     DX,RS232_BASE[SI]
E7E7 83C205                  ADD     DX,5                    ; CONTROL PORT
E7EA EC                      IN      AL,DX                   ; GET LINE CONTROL STATUS
E7EB 8AE0                    MOV     AH,AL                   ; PUT IN AH FOR RETURN
E7ED 42                      INC     DX                      ; POINT TO MODEM STATUS REGISTER
E7EE EC                      IN      AL,DX                   ; GET MODEM CONTROL STATUS
E7EF E970FF                  JMP     A3                      ; RETURN
                     ;--------------------------------------
                     ; WAIT FOR STATUS ROUTINE              :
                     ;                                      :
                     ; ENTRY:                               :
                     ;       BH=STATUS BIT(S) TO LOOK FOR,  :
                     ;       DX=ADDR. OF STATUS REG         :
                     ; EXIT:                                :
                     ;       ZERO FLAG ON  = STATUS FOUND   :
                     ;       ZERO FLAG OFF = TIMEOUT.       :
                     ;       AH=LAST STATUS READ            :
                     ;--------------------------------------
E7F2                 WAIT_FOR_STATUS PROC    NEAR
E7F2 8A5D7C                  MOV     BL,RS232_TIM_OUT[DI]    ; LOAD OUTER LOOP COUNT
E7F5                 WFS0:
E7F5 2BC9                    SUB     CX,CX
E7F7                 WFS1:
E7F7 EC                      IN      AL,DX                   ; GET STATUS
E7F8 8AE0                    MOV     AH,AL                   ; MOVE TO AH
E7FA 22C7                    AND     AL,BH                   ; ISOLATE BITS TO TEST
E7FC 3AC7                    CMP     AL,BH                   ; EXACTLY = TO MASK
E7FE 7408                    JE      WFS_END                 ; RETURN WITH ZERO FLAG ON
E800 E2F5                    LOOP    WFS1                    ; TRY AGAIN
E802 FECB                    DEC     BL
E804 75EF                    JNZ     WFS0
E806 0AFF                    OR      BH,BH                   ; SET ZERO FLAG OFF
E808                 WFS_END:
E808 C3                      RET
                     WAIT_FOR_STATUS ENDP
                     RS232_IO        ENDP

                     ;------------------------------------------------------------------
                     ;       PRINT ADDRESS AND ERROR MESSAGE FOR ROM CHECKSUM ERRORS    :
                     ;------------------------------------------------------------------
E809                 ROM_ERR PROC    NEAR
E809 52                      PUSH    DX                      ; SAVE POINTER
E80A 50                      PUSH    AX
E80B 8CDA                    MOV     DX,DS                   ; GET ADDRESS POINTER
E80D 81FA00C8                CMP     DX,0C800H
E811 7E13                    JLE     ROM_ERR_BEEP            ; SPECIAL ERROR INDICATION
E813 8AC6                    MOV     AL,DH
E815 E80DFE                  CALL    XPC_BYTE                ; DISPLAY ADDRESS
E818 8AC2                    MOV     AL,DL
E81A E808FE                  CALL    XPC_BYTE
E81D BED7E6                  MOV     SI,OFFSET F3A           ; DISPLAY ERROR MSG
E820 E897FE                  CALL    P_MSG
E823                 ROM_ERR_END:
E823 58                      POP     AX
E824 5A                      POP     DX
E825 C3                      RET
E826                 ROM_ERR_BEEP:
E826 BA0201                  MOV     DX,0102H                ; BEEP 1 LONG, 2 SHORT
E829 E8A3FD                  CALL    ERR_BEEP
E82C EBF5                    JMP     SHORT ROM_ERR_END
```

```
LOC OBJ                 SOURCE

                        ROM_ERR ENDP

                        ;---- INT 16 ------------------------------------------------------------
                        ; KEYBOARD I/O                                                          :
                        ;       THESE ROUTINES PROVIDE KEYBOARD SUPPORT                         :
                        ; INPUT                                                                 :
                        ;       (AH)=0  READ THE NEXT ASCII CHARACTER STRUCK FROM THE KEYBOARD  :
                        ;               RETURN THE RESULT IN (AL), SCAN CODE IN (AH)            :
                        ;       (AH)=1  SET THE Z FLAG TO INDICATE IF AN ASCII CHARACTER IS     :
                        ;               AVAILABLE TO BE READ.                                   :
                        ;               (ZF)=1 -- NO CODE AVAILABLE                             :
                        ;               (ZF)=0 -- CODE IS AVAILABLE                             :
                        ;               IF ZF = 0, THE NEXT CHARACTER IN THE BUFFER TO BE READ  :
                        ;               IS IN AX, AND THE ENTRY REMAINS IN THE BUFFER           :
                        ;       (AH)=2  RETURN THE CURRENT SHIFT STATUS IN AL REGISTER          :
                        ;               THE BIT SETTINGS FOR THIS CODE ARE INDICATED IN THE     :
                        ;               THE EQUATES FOR KB_FLAG                                 :
                        ; OUTPUT                                                                :
                        ;       AS NOTED ABOVE, ONLY AX AND FLAGS CHANGED                       :
                        ;       ALL REGISTERS PRESERVED                                         :
                        ;------------------------------------------------------------------------
                                ASSUME  CS:CODE,DS:DATA
E82E                            ORG     0E82EH
E82E                    KEYBOARD_IO     PROC    FAR
E82E FB                         STI                             ; INTERRUPTS BACK ON
E82F 1E                         PUSH    DS                      ; SAVE CURRENT DS
E830 53                         PUSH    BX                      ; SAVE BX TEMPORARILY
E831 E80A17                     CALL    DDS
E834 0AE4                       OR      AH,AH                   ; AH=0
E836 740A                       JZ      K1                      ; ASCII_READ
E838 FECC                       DEC     AH                      ; AH=1
E83A 741E                       JZ      K2                      ; ASCII_STATUS
E83C FECC                       DEC     AH                      ; AH=2
E83E 742B                       JZ      K3                      ; SHIFT_STATUS
E840 EB2C                       JMP     SHORT INT10_END         ; EXIT

                        ;----- READ THE KEY TO FIGURE OUT WHAT TO DO

E842                    K1:                                     ; ASCII READ
E842 FB                         STI                             ; INTERRUPTS BACK ON DURING LOOP
E843 90                         NOP                             ; ALLOW AN INTERRUPT TO OCCUR
E844 FA                         CLI                             ; INTERRUPTS BACK OFF
E845 8B1E1A00                   MOV     BX,BUFFER_HEAD          ; GET POINTER TO HEAD OF BUFFER
E849 3B1E1C00                   CMP     BX,BUFFER_TAIL          ; TEST END OF BUFFER
E84D 74F3                       JZ      K1                      ; LOOP UNTIL SOMETHING IN BUFFER
E84F 8B07                       MOV     AX,[BX]                 ; GET SCAN CODE AND ASCII CODE
E851 E81D00                     CALL    K4                      ; MOVE POINTER TO NEXT POSITION
E854 891E1A00                   MOV     BUFFER_HEAD,BX          ; STORE VALUE IN VARIABLE
E858 EB14                       JMP     SHORT INT10_END         ; RETURN

                        ;----- ASCII STATUS

E85A                    K2:
E85A FA                         CLI                             ; INTERRUPTS OFF
E85B 8B1E1A00                   MOV     BX,BUFFER_HEAD          ; GET HEAD POINTER
E85F 3B1E1C00                   CMP     BX,BUFFER_TAIL          ; IF EQUAL (Z=1) THEN NOTHING THERE
E863 8B07                       MOV     AX,[BX]
E865 FB                         STI                             ; INTERRUPTS BACK ON
E866 5B                         POP     BX                      ; RECOVER REGISTER
E867 1F                         POP     DS                      ; RECOVER SEGMENT
E868 CA0200                     RET     2                       ; THROW AWAY FLAGS

                        ;----- SHIFT STATUS

E86B                    K3:
E86B A01700                     MOV     AL,KB_FLAG              ; GET THE SHIFT STATUS FLAGS
E86E                    INT10_END:
E86E 5B                         POP     BX                      ; RECOVER REGISTER
E86F 1F                         POP     DS                      ; RECOVER REGISTERS
E870 CF                         IRET                            ; RETURN TO CALLER
                        KEYBOARD_IO     ENDP

                        ;----- INCREMENT A BUFFER POINTER

E871                    K4      PROC    NEAR
E871 43                         INC     BX                      ; MOVE TO NEXT WORD IN LIST
E872 43                         INC     BX
```

```
LOC OBJ                 LINE    SOURCE

E873 3B1E8200                           CMP     BX,BUFFER_END           ; AT END OF BUFFER?
E877 7504                               JNE     K5                      ; NO, CONTINUE
E879 8B1E8000                           MOV     BX,BUFFER_START         ; YES, RESET TO BUFFER BEGINNING
E87D                            K5:
E87D C3                                 RET
                                K4      ENDP
                                ;----- TABLE OF SHIFT KEYS AND MASK VALUES
E87E                            K6      LABEL   BYTE
E87E 52                                 DB      INS_KEY                 ; INSERT KEY
E87F 3A                                 DB      CAPS_KEY,NUM_KEY,SCROLL_KEY,ALT_KEY,CTL_KEY
E880 45
E881 46
E882 38
E883 1D
E884 2A                                 DB      LEFT_KEY,RIGHT_KEY
E885 36
 0008                           K6L     EQU     $-K6
                                ;----- SHIFT_MASK_TABLE
E886                            K7      LABEL   BYTE
E886 80                                 DB      INS_SHIFT               ; INSERT MODE SHIFT
E887 40                                 DB      CAPS_SHIFT,NUM_SHIFT,SCROLL_SHIFT,ALT_SHIFT,CTL_SHIFT
E888 20
E889 10
E88A 08
E88B 04
E88C 02                                 DB      LEFT_SHIFT,RIGHT_SHIFT
E88D 01
                                ;----- SCAN CODE TABLES
E88E 1B                         K8              DB      27,-1,0,-1,-1,-1,30,-1
E88F FF
E890 00
E891 FF
E892 FF
E893 FF
E894 1E
E895 FF
E896 FF                                         DB      -1,-1,-1,31,-1,127,-1,17
E897 FF
E898 FF
E899 1F
E89A FF
E89B 7F
E89C FF
E89D 11
E89E 17                                         DB      23,5,18,20,25,21,9,15
E89F 05
E8A0 12
E8A1 14
E8A2 19
E8A3 15
E8A4 09
E8A5 0F
E8A6 10                                         DB      16,27,29,10,-1,1,19
E8A7 1B
E8A8 1D
E8A9 0A
E8AA FF
E8AB 01
E8AC 13
E8AD 04                                         DB      4,6,7,8,10,11,12,-1,-1
E8AE 06
E8AF 07
E8B0 08
E8B1 0A
E8B2 0B
E8B3 0C
E8B4 FF
E8B5 FF
E8B6 FF                                         DB      -1,-1,28,26,24,3,22,2
E8B7 FF
E8B8 1C
```

Section 5

```
LOC OBJ                LINE    SOURCE

E8B9 1A
E8BA 18
E8BB 03
E8BC 16
E8BD 02
E8BE 0E                1923                    DB      14,13,-1,-1,-1,-1,-1,-1
E8BF 0D
E8C0 FF
E8C1 FF
E8C2 FF
E8C3 FF
E8C4 FF
E8C5 FF
E8C6 20                1924                    DB      ' ',-1
E8C7 FF
                       1925    ;----- CTL TABLE SCAN
E8C8                   1926    K9      LABEL   BYTE
E8C8 5E                1927                    DB      94,95,96,97,98,99,100,101
E8C9 5F
E8CA 60
E8CB 61
E8CC 62
E8CD 63
E8CE 64
E8CF 65
E8D0 66                1928                    DB      102,103,-1,-1,119,-1,132,-1
E8D1 67
E8D2 FF
E8D3 FF
E8D4 77
E8D5 FF
E8D6 84
E8D7 FF
E8D8 73                1929                    DB      115,-1,116,-1,117,-1,118,-1
E8D9 FF
E8DA 74
E8DB FF
E8DC 75
E8DD FF
E8DE 76
E8DF FF
E8E0 FF                1930                    DB      -1
                       1931    ;----- LC TABLE
E8E1                   1932    K10     LABEL   BYTE
E8E1 1B                1933                    DB      01BH,'1234567890-=',08H,09H
E8E2 31323334353637
     3839302D3D
E8EE 08
E8EF 09
E8F0 71776572747975    1934                    DB      'qwertyuiop[]',0DH,-1,'asdfghjkl;',027H
     696F705B5D
E8FC 0D
E8FD FF
E8FE 6173646667686A
     6B6C3B
E908 27
E909 60                1935                    DB      60H,-1,5CH,'zxcvbnm,./',-1,'*',-1,' '
E90A FF
E90B 5C
E90C 7A786376626E6D
     2C2E2F
E916 FF
E917 2A
E918 FF
E919 20
E91A FF                1936                    DB      -1
                       1937    ;----- UC TABLE
E91B                   1938    K11     LABEL   BYTE
E91B 1B                1939                    DB      27,'!@#$',37,05EH,'&*()_+',08H,0
E91C 21402324
E920 25
E921 5E
E922 262A28295F2B
E928 08
E929 00
E92A 51574552545955    1940                    DB      'QWERTYUIOP{}',0DH,-1,'ASDFGHJKL:"'
     494F507B7D
```

```
LOC OBJ                    LINE   SOURCE

E936 0D
E937 FF
E938 4153444647484A
     4B4C3A22
E943 7E                    1941                 DB      07EH,-1,'|ZXCVBNM<>?',-1,0,-1,' ',-1
E944 FF
E945 7C5A584356424E
     4D3C3E3F
E950 FF
E951 00
E952 FF
E953 20
E954 FF
                           1942   ;----- UC TABLE SCAN
E955                       1943   K12     LABEL  BYTE
E955 54                    1944                 DB      84,85,86,87,88,89,90
E956 55
E957 56
E958 57
E959 58
E95A 59
E95B 5A
E95C 5B                    1945                 DB      91,92,93
E95D 5C
E95E 5D
                           1946   ;----- ALT TABLE SCAN
E95F                       1947   K13     LABEL  BYTE
E95F 68                    1948                 DB      104,105,106,107,108
E960 69
E961 6A
E962 6B
E963 6C
E964 6D                    1949                 DB      109,110,111,112,113
E965 6E
E966 6F
E967 70
E968 71
                           1950   ;----- NUM STATE TABLE
E969                       1951   K14     LABEL  BYTE
E969 3738392D343536        1952                 DB      '789-456+1230.'
     2B313233302E
                           1953   ;----- BASE CASE TABLE
E976                       1954   K15     LABEL  BYTE
E976 47                    1955                 DB      71,72,73,-1,75,-1,77
E977 48
E978 49
E979 FF
E97A 4B
E97B FF
E97C 4D
E97D FF                    1956                 DB      -1,79,80,81,82,83
E97E 4F
E97F 50
E980 51
E981 52
E982 53
                           1957
                           1958   ;----- KEYBOARD INTERRUPT ROUTINE
                           1959
E987                       1960           ORG    0E987H
E987                       1961   KB_INT  PROC   FAR
E987 FB                    1962           STI                         ; ALLOW FURTHER INTERRUPTS
E988 50                    1963           PUSH   AX
E989 53                    1964           PUSH   BX
E98A 51                    1965           PUSH   CX
E98B 52                    1966           PUSH   DX
E98C 56                    1967           PUSH   SI
E98D 57                    1968           PUSH   DI
E98E 1E                    1969           PUSH   DS
E98F 06                    1970           PUSH   ES
E990 FC                    1971           CLD                         ; FORWARD DIRECTION
E991 E8AA15                1972           CALL   DDS
E994 E460                  1973           IN     AL,KB_DATA           ; READ IN THE CHARACTER
E996 50                    1974           PUSH   AX                   ; SAVE IT
E997 E461                  1975           IN     AL,KB_CTL            ; GET THE CONTROL PORT
E999 8AE0                  1976           MOV    AH,AL                ; SAVE VALUE
E99B 0C80                  1977           OR     AL,80H               ; RESET BIT FOR KEYBOARD
```

```
LOC OBJ               LINE    SOURCE

E99D E661                         OUT    KB_CTL,AL
E99F 86E0                         XCHG   AH,AL                    ; GET BACK ORIGINAL CONTROL
E9A1 E661                         OUT    KB_CTL,AL                ; KB HAS BEEN RESET
E9A3 58                           POP    AX                       ; RECOVER SCAN CODE
E9A4 8AE0                         MOV    AH,AL                    ; SAVE SCAN CODE IN AH ALSO

                              ;----- TEST FOR OVERRUN SCAN CODE FROM KEYBOARD

E9A6 3CFF                         CMP    AL,0FFH                  ; IS THIS AN OVERRUN CHAR
E9A8 7503                         JNZ    K16                      ; NO, TEST FOR SHIFT KEY
E9AA E97A02                       JMP    K62                      ; BUFFER_FULL_BEEP

                              ;----- TEST FOR SHIFT KEYS

E9AD                          K16:                                ; TEST_SHIFT
E9AD 247F                         AND    AL,07FH                  ; TURN OFF THE BREAK BIT
E9AF 0E                           PUSH   CS
E9B0 07                           POP    ES                       ; ESTABLISH ADDRESS OF SHIFT TABLE
E9B1 BF7EE8                       MOV    DI,OFFSET K6             ; SHIFT KEY TABLE
E9B4 B90800                       MOV    CX,K6L                   ; LENGTH
E9B7 F2                           REPNE  SCASB                    ; LOOK THROUGH THE TABLE FOR A MATCH
E9B8 AE
E9B9 8AC4                         MOV    AL,AH                    ; RECOVER SCAN CODE
E9BB 7403                         JE     K17                      ; JUMP IF MATCH FOUND
E9BD E98500                       JMP    K25                      ; IF NO MATCH, THEN SHIFT NOT FOUND

                              ;----- SHIFT KEY FOUND

E9C0 81EF7FE8                 K17:  SUB    DI,OFFSET K6+1         ; ADJUST PTR TO SCAN CODE MTCH
E9C4 2E8AA586E8                   MOV    AH,CS:K7[DI]             ; GET MASK INTO AH
E9C9 A880                         TEST   AL,80H                   ; TEST FOR BREAK KEY
E9CB 7551                         JNZ    K23                      ; BREAK_SHIFT_FOUND

                              ;----- SHIFT MAKE FOUND, DETERMINE SET OR TOGGLE

E9CD 80FC10                       CMP    AH,SCROLL_SHIFT
E9D0 7307                         JAE    K18                      ; IF SCROLL SHIFT OR ABOVE, TOGGLE KEY

                              ;----- PLAIN SHIFT KEY, SET SHIFT ON

E9D2 08261700                     OR     KB_FLAG,AH               ; TURN ON SHIFT BIT
E9D6 E98000                       JMP    K26                      ; INTERRUPT_RETURN

                              ;----- TOGGLED SHIFT KEY, TEST FOR 1ST MAKE OR NOT

E9D9                          K18:                                ; SHIFT-TOGGLE
E9D9 F606170004                   TEST   KB_FLAG, CTL_SHIFT       ; CHECK CTL SHIFT STATE
E9DE 7565                         JNZ    K25                      ; JUMP IF CTL STATE
E9E0 3C52                         CMP    AL, INS_KEY              ; CHECK FOR INSERT KEY
E9E2 7522                         JNZ    K22                      ; JUMP IF NOT INSERT KEY
E9E4 F606170008                   TEST   KB_FLAG, ALT_SHIFT       ; CHECK FOR ALTERNATE SHIFT
E9E9 755A                         JNZ    K25                      ; JUMP IF ALTERNATE SHIFT
E9EB F606170020               K19:  TEST   KB_FLAG, NUM_STATE     ; CHECK FOR BASE STATE
E9F0 750D                         JNZ    K21                      ; JUMP IF NUM LOCK IS ON
E9F2 F606170003                   TEST   KB_FLAG, LEFT_SHIFT+ RIGHT_SHIFT
E9F7 740D                         JZ     K22                      ; JUMP IF BASE STATE

E9F9                          K20:                                ; NUMERIC ZERO, NOT INSERT KEY
E9F9 B83052                       MOV    AX, 5230H                ; PUT OUT AN ASCII ZERO
E9FC E9D601                       JMP    K57                      ; BUFFER_FILL
E9FF                          K21:                                ; MIGHT BE NUMERIC
E9FF F606170003                   TEST   KB_FLAG, LEFT_SHIFT+ RIGHT_SHIFT
EA04 74F3                         JZ     K20                      ; JUMP NUMERIC, NOT INSERT

EA06                          K22:                                ; SHIFT TOGGLE KEY HIT; PROCESS IT
EA06 84261800                     TEST   AH,KB_FLAG_1             ; IS KEY ALREADY DEPRESSED
EA0A 754D                         JNZ    K26                      ; JUMP IF KEY ALREADY DEPRESSED
EA0C 08261800                     OR     KB_FLAG_1,AH             ; INDICATE THAT THE KEY IS DEPRESSED
EA10 30261700                     XOR    KB_FLAG,AH               ; TOGGLE THE SHIFT STATE
EA14 3C52                         CMP    AL,INS_KEY               ; TEST FOR 1ST MAKE OF INSERT KEY
EA16 7541                         JNE    K26                      ; JUMP IF NOT INSERT KEY
EA18 B80052                       MOV    AX,INS_KEY*256           ; SET SCAN CODE INTO AH, 0 INTO AL
EA1B E9B701                       JMP    K57                      ; PUT INTO OUTPUT BUFFER

                              ;----- BREAK SHIFT FOUND

EA1E                          K23:                                ; BREAK-SHIFT-FOUND
```

```
LOC OBJ                SOURCE

EA1E 80FC10                  CMP    AH,SCROLL_SHIFT       ; IS THIS A TOGGLE KEY
EA21 731A                    JAE    K24                   ; YES, HANDLE BREAK TOGGLE
EA23 F6D4                    NOT    AH                    ; INVERT MASK
EA25 20261700                AND    KB_FLAG,AH            ; TURN OFF SHIFT BIT
EA29 3CB8                    CMP    AL,ALT_KEY+80H        ; IS THIS ALTERNATE SHIFT RELEASE
EA2B 752C                    JNE    K26                   ; INTERRUPT_RETURN

                       ;----- ALTERNATE SHIFT KEY RELEASED, GET THE VALUE INTO BUFFER

EA2D A01900                  MOV    AL,ALT_INPUT
EA30 B400                    MOV    AH,0                  ; SCAN CODE OF 0
EA32 88261900                MOV    ALT_INPUT,AH          ; ZERO OUT THE FIELD
EA36 3C00                    CMP    AL,0                  ; WAS THE INPUT=0
EA38 741F                    JE     K26                   ; INTERRUPT_RETURN
EA3A E9A101                  JMP    K58                   ; IT WASN'T, SO PUT IN BUFFER
EA3D                   K24:                               ; BREAK-TOGGLE
EA3D F6D4                    NOT    AH                    ; INVERT MASK
EA3F 20261800                AND    KB_FLAG_1,AH          ; INDICATE NO LONGER DEPRESSED
EA43 EB14                    JMP    SHORT K26             ; INTERRUPT_RETURN

                       ;----- TEST FOR HOLD STATE

EA45                   K25:                               ; NO-SHIFT-FOUND
EA45 3C80                    CMP    AL,80H                ; TEST FOR BREAK KEY
EA47 7310                    JAE    K26                   ; NOTHING FOR BREAK CHARS FROM HERE ON
EA49 F606180008              TEST   KB_FLAG_1,HOLD_STATE  ; ARE WE IN HOLD STATE
EA4E 7417                    JZ     K28                   ; BRANCH AROUND TEST IF NOT
EA50 3C45                    CMP    AL,NUM_KEY
EA52 7405                    JE     K26                   ; CAN'T END HOLD ON NUM_LOCK
EA54 80261800F7              AND    KB_FLAG_1,NOT HOLD_STATE       ; TURN OFF THE HOLD STATE BIT
EA59                   K26:                               ; INTERRUPT-RETURN
EA59 FA                      CLI                          ; TURN OFF INTERRUPTS
EA5A B020                    MOV    AL,EOI                ; END OF INTERRUPT COMMAND
EA5C E620                    OUT    020H,AL               ; SEND COMMAND TO INT CONTROL PORT
EA5E                   K27:                               ; INTERRUPT-RETURN-NO-EOI
EA5E 07                      POP    ES
EA5F 1F                      POP    DS
EA60 5F                      POP    DI
EA61 5E                      POP    SI
EA62 5A                      POP    DX
EA63 59                      POP    CX
EA64 5B                      POP    BX
EA65 58                      POP    AX                    ; RESTORE STATE
EA66 CF                      IRET                         ; RETURN, INTERRUPTS BACK ON
                                                          ;  WITH FLAG CHANGE

                       ;----- NOT IN  HOLD STATE, TEST FOR SPECIAL CHARS

EA67                   K28:                               ; NO-HOLD-STATE
EA67 F606170008              TEST   KB_FLAG,ALT_SHIFT     ; ARE WE IN ALTERNATE SHIFT
EA6C 7503                    JNZ    K29                   ; JUMP IF ALTERNATE SHIFT
EA6E E99100                  JMP    K38                   ; JUMP IF NOT ALTERNATE

                       ;----- TEST FOR RESET KEY SEQUENCE (CTL ALT DEL)

EA71                   K29:                               ; TEST-RESET
EA71 F606170004              TEST   KB_FLAG,CTL_SHIFT     ; ARE WE IN CONTROL SHIFT ALSO
EA76 7433                    JZ     K31                   ; NO_RESET
EA78 3C53                    CMP    AL,DEL_KEY            ; SHIFT STATE IS THERE, TEST KEY
EA7A 752F                    JNE    K31                   ; NO_RESET

                       ;----- CTL-ALT-DEL HAS BEEN FOUND, DO I/O CLEANUP

EA7C C70672003412            MOV    RESET_FLAG, 1234H     ; SET FLAG FOR RESET FUNCTION
EA82 EA5BE000F0              JMP    RESET                 ; JUMP TO POWER ON DIAGNOSTICS

                       ;----- ALT-INPUT-TABLE
EA87                   K30   LABEL  BYTE
EA87 52                      DB     82,79,80,81,75,76,77
EA88 4F
EA89 50
EA8A 51
EA8B 4B
EA8C 4C
EA8D 4D
EA8E 47                      DB     71,72,73              ; 10 NUMBERS ON KEYPAD
EA8F 48
```

Section 5

```
LOC OBJ              LINE     SOURCE

EA90 49
                              ;----- SUPER-SHIFT-TABLE
EA91 10                             DB      16,17,18,19,20,21,22,23 ; A-Z TYPEWRITER CHARS
EA92 11
EA93 12
EA94 13
EA95 14
EA96 15
EA97 16
EA98 17
EA99 18                             DB      24,25,30,31,32,33,34,35
EA9A 19
EA9B 1E
EA9C 1F
EA9D 20
EA9E 21
EA9F 22
EAA0 23
EAA1 24                             DB      36,37,38,44,45,46,47,48
EAA2 25
EAA3 26
EAA4 2C
EAA5 2D
EAA6 2E
EAA7 2F
EAA8 30
EAA9 31                             DB      49,50
EAAA 32

                              ;----- IN ALTERNATE SHIFT, RESET NOT FOUND

EAAB                          K31:                                  ; NO-RESET
EAAB 3C39                           CMP     AL,57                   ; TEST FOR SPACE KEY
EAAD 7505                           JNE     K32                     ; NOT THERE
EAAF B020                           MOV     AL,' '                  ; SET SPACE CHAR
EAB1 E92101                         JMP     K57                     ; BUFFER_FILL

                              ;----- LOOK FOR KEY PAD ENTRY

EAB4                          K32:                                  ; ALT-KEY-PAD
EAB4 BF87EA                         MOV     DI,OFFSET K30           ; ALT-INPUT-TABLE
EAB7 B90A00                         MOV     CX,10                   ; LOOK FOR ENTRY USING KEYPAD
EABA F2                             REPNE   SCASB                   ; LOOK FOR MATCH
EABB AE
EABC 7512                           JNE     K33                     ; NO_ALT_KEYPAD
EABE 81EF88EA                       SUB     DI,OFFSET K30+1         ; DI NOW HAS ENTRY VALUE
EAC2 A01900                         MOV     AL,ALT_INPUT            ; GET THE CURRENT BYTE
EAC5 B40A                           MOV     AH,10                   ; MULTIPLY BY 10
EAC7 F6E4                           MUL     AH
EAC9 03C7                           ADD     AX,DI                   ; ADD IN THE LATEST ENTRY
EACB A21900                         MOV     ALT_INPUT,AL            ; STORE IT AWAY
EACE EB89                           JMP     K26                     ; THROW AWAY THAT KEYSTROKE

                              ;----- LOOK FOR SUPERSHIFT ENTRY

EAD0                          K33:                                  ; NO-ALT-KEYPAD
EAD0 C606190000                     MOV     ALT_INPUT,0             ; ZERO ANY PREVIOUS ENTRY INTO INPUT
EAD5 B91A00                         MOV     CX,26                   ; DI,ES ALREADY POINTING
EAD8 F2                             REPNE   SCASB                   ; LOOK FOR MATCH IN ALPHABET
EAD9 AE
EADA 7505                           JNE     K34                     ; NOT FOUND, FUNCTION KEY OR OTHER
EADC B000                           MOV     AL,0                    ; ASCII CODE OF ZERO
EADE E9F400                         JMP     K57                     ; PUT IT IN THE BUFFER

                              ;----- LOOK FOR TOP ROW OF ALTERNATE SHIFT

EAE1                          K34:                                  ; ALT-TOP-ROW
EAE1 3C02                           CMP     AL,2                    ; KEY WITH '1' ON IT
EAE3 720C                           JB      K35                     ; NOT ONE OF INTERESTING KEYS
EAE5 3C0E                           CMP     AL,14                   ; IS IT IN THE REGION
EAE7 7308                           JAE     K35                     ; ALT-FUNCTION
EAE9 80C476                         ADD     AH,118                  ; CONVERT PSUEDO SCAN CODE TO RANGE
EAEC B000                           MOV     AL,0                    ; INDICATE AS SUCH
EAEE E9E400                         JMP     K57                     ; BUFFER_FILL

                              ;----- TRANSLATE ALTERNATE SHIFT PSEUDO SCAN CODES

```

```
LOC OBJ            SOURCE

EAF1               K35:                                   ; ALT-FUNCTION
EAF1 3C3B                  CMP     AL,59                  ; TEST FOR IN TABLE
EAF3 7303                  JAE     K37                    ; ALT-CONTINUE
EAF5               K36:                                   ; CLOSE-RETURN
EAF5 E961FF                JMP     K26                    ; IGNORE THE KEY
EAF8               K37:                                   ; ALT-CONTINUE
EAF8 3C47                  CMP     AL,71                  ; IN KEYPAD REGION
EAFA 73F9                  JAE     K36                    ; IF SO, IGNORE
EAFC BB5FE9                MOV     BX,OFFSET K13          ; ALT SHIFT PSEUDO SCAN TABLE
EAFF E91B01                JMP     K63                    ; TRANSLATE THAT

                   ;----- NOT IN ALTERNATE SHIFT

EB02               K38:                                   ; NOT-ALT-SHIFT
EB02 F606170004            TEST    KB_FLAG,CTL_SHIFT      ; ARE WE IN CONTROL SHIFT
EB07 7458                  JZ      K44                    ; NOT-CTL-SHIFT

                   ;----- CONTROL SHIFT, TEST SPECIAL CHARACTERS
                   ;----- TEST FOR BREAK AND PAUSE KEYS

EB09 3C46                  CMP     AL,SCROLL_KEY          ; TEST FOR BREAK
EB0B 7518                  JNE     K39                    ; NO-BREAK
EB0D 8B1E8000              MOV     BX,BUFFER_START        ; RESET BUFFER TO EMPTY
EB11 891E1A00              MOV     BUFFER_HEAD,BX
EB15 891E1C00              MOV     BUFFER_TAIL,BX
EB19 C606710080            MOV     BIOS_BREAK,80H         ; TURN ON BIOS_BREAK BIT
EB1E CD1B                  INT     1BH                    ; BREAK INTERRUPT VECTOR
EB20 2BC0                  SUB     AX,AX                  ; PUT OUT DUMMY CHARACTER
EB22 E9B000                JMP     K57                    ; BUFFER_FILL
EB25               K39:                                   ; NO-BREAK
EB25 3C45                  CMP     AL,NUM_KEY             ; LOOK FOR PAUSE KEY
EB27 7521                  JNE     K41                    ; NO-PAUSE
EB29 800E180008            OR      KB_FLAG_1,HOLD_STATE   ; TURN ON THE HOLD FLAG
EB2E B020                  MOV     AL,EOI                 ; END OF INTERRUPT TO CONTROL PORT
EB30 E620                  OUT     020H,AL                ; ALLOW FURTHER KEYSTROKE INTS

                   ;----- DURING PAUSE INTERVAL, TURN CRT BACK ON

EB32 803E490007            CMP     CRT_MODE,7             ; IS THIS BLACK AND WHITE CARD
EB37 7407                  JE      K40                    ; YES, NOTHING TO DO
EB39 BAD803                MOV     DX,03D8H               ; PORT FOR COLOR CARD
EB3C A06500                MOV     AL,CRT_MODE_SET        ; GET THE VALUE OF THE CURRENT MODE
EB3F EE                    OUT     DX,AL                  ; SET THE CRT MODE, SO THAT CRT IS ON
EB40               K40:                                   ; PAUSE-LOOP
EB40 F606180008            TEST    KB_FLAG_1,HOLD_STATE
EB45 75F9                  JNZ     K40                    ; LOOP UNTIL FLAG TURNED OFF
EB47 E914FF                JMP     K27                    ; INTERRUPT_RETURN_NO_EOI
EB4A               K41:                                   ; NO-PAUSE

                   ;----- TEST SPECIAL CASE KEY 55

EB4A 3C37                  CMP     AL,55
EB4C 7506                  JNE     K42                    ; NOT-KEY-55
EB4E B80072                MOV     AX,114*256             ; START/STOP PRINTING SWITCH
EB51 E98100                JMP     K57                    ; BUFFER_FILL

                   ;----- SET UP TO TRANSLATE CONTROL SHIFT

EB54               K42:                                   ; NOT-KEY-55
EB54 BB8EE8                MOV     BX,OFFSET K8           ; SET UP TO TRANSLATE CTL
EB57 3C3B                  CMP     AL,59                  ; IS IT IN TABLE
                                                          ; CTL-TABLE-TRANSLATE
EB59 7276                  JB      K56                    ; YES, GO TRANSLATE CHAR
EB5B               K43:                                   ; CTL-TABLE-TRANSLATE
EB5B BBC8E8                MOV     BX,OFFSET K9           ; CTL TABLE SCAN
EB5E E9BC00                JMP     K63                    ; TRANSLATE_SCAN

                   ;----- NOT IN CONTROL SHIFT

EB61               K44:                                   ; NOT-CTL-SHIFT
EB61 3C47                  CMP     AL,71                  ; TEST FOR KEYPAD REGION
EB63 732C                  JAE     K48                    ; HANDLE KEYPAD REGION
EB65 F606170003            TEST    KB_FLAG,LEFT_SHIFT+RIGHT_SHIFT
EB6A 745A                  JZ      K54                    ; TEST FOR SHIFT STATE

                   ;----- UPPER CASE, HANDLE SPECIAL CASES
```

```
LOC OBJ                 LINE    SOURCE

EB6C 3C0F                               CMP     AL,15                   ; BACK TAB KEY
EB6E 7505                               JNE     K45                     ; NOT-BACK-TAB
EB70 B8000F                             MOV     AX,15*256               ; SET PSEUDO SCAN CODE
EB73 EB60                               JMP     SHORT K57               ; BUFFER_FILL
EB75                            K45:                                    ; NOT-BACK-TAB
EB75 3C37                               CMP     AL,55                   ; PRINT SCREEN KEY
EB77 7509                               JNE     K46                     ; NOT-PRINT-SCREEN

                                ;----- ISSUE INTERRUPT TO INDICATE PRINT SCREEN FUNCTION

EB79 B020                               MOV     AL,EOI                  ; END OF CURRENT INTERRUPT
EB7B E620                               OUT     020H,AL                 ;  SO FURTHER THINGS CAN HAPPEN
EB7D CD05                               INT     5H                      ; ISSUE PRINT SCREEN INTERRUPT
EB7F E9DCFE                             JMP     K27                     ; GO BACK WITHOUT EOI OCCURRING
EB82                            K46:                                    ; NOT-PRINT-SCREEN
EB82 3C3B                               CMP     AL,59                   ; FUNCTION KEYS
EB84 7206                               JB      K47                     ; NOT-UPPER-FUNCTION
EB86 BB55E9                             MOV     BX,OFFSET K12           ; UPPER CASE PSEUDO SCAN CODES
EB89 E99100                             JMP     K63                     ; TRANSLATE_SCAN
EB8C                            K47:                                    ; NOT-UPPER-FUNCTION
EB8C BB1BE9                             MOV     BX,OFFSET K11           ; POINT TO UPPER CASE TABLE
EB8F EB40                               JMP     SHORT K56               ; OK, TRANSLATE THE CHAR

                                ;----- KEYPAD KEYS, MUST TEST NUM LOCK FOR DETERMINATION

EB91                            K48:                                    ; KEYPAD-REGION
EB91 F606170020                         TEST    KB_FLAG,NUM_STATE       ; ARE WE IN NUM_LOCK
EB96 7520                               JNZ     K52                     ; TEST FOR SURE
EB98 F606170003                         TEST    KB_FLAG,LEFT_SHIFT+RIGHT_SHIFT  ; ARE WE IN SHIFT STATE
EB9D 7520                               JNZ     K53                     ; IF SHIFTED, REALLY NUM STATE

                                ;----- BASE CASE FOR KEYPAD

EB9F                            K49:                                    ; BASE-CASE
EB9F 3C4A                               CMP     AL,74                   ; SPECIAL CASE FOR A COUPLE OF KEYS
EBA1 740B                               JE      K50                     ; MINUS
EBA3 3C4E                               CMP     AL,78
EBA5 740C                               JE      K51
EBA7 2C47                               SUB     AL,71                   ; CONVERT ORIGIN
EBA9 BB76E9                             MOV     BX,OFFSET K15           ; BASE CASE TABLE
EBAC EB71                               JMP     SHORT K64               ; CONVERT TO PSEUDO SCAN
EBAE                            K50:
EBAE B82D4A                             MOV     AX,74*256+'-'           ; MINUS
EBB1 EB22                               JMP     SHORT K57               ; BUFFER_FILL
EBB3                            K51:
EBB3 B82B4E                             MOV     AX,78*256+'+'           ; PLUS
EBB6 EB1D                               JMP     SHORT K57               ; BUFFER_FILL

                                ;----- MIGHT BE NUM LOCK, TEST SHIFT STATUS

EBB8                            K52:                                    ; ALMOST-NUM-STATE
EBB8 F606170003                         TEST    KB_FLAG,LEFT_SHIFT+RIGHT_SHIFT
EBBD 75E0                               JNZ     K49                     ; SHIFTED TEMP OUT OF NUM STATE
EBBF                            K53:                                    ; REALLY_NUM_STATE
EBBF 2C46                               SUB     AL,70                   ; CONVERT ORIGIN
EBC1 BB69E9                             MOV     BX,OFFSET K14           ; NUM STATE TABLE
EBC4 EB0B                               JMP     SHORT K56               ; TRANSLATE_CHAR

                                ;----- PLAIN OLD LOWER CASE

EBC6                            K54:                                    ; NOT-SHIFT
EBC6 3C3B                               CMP     AL,59                   ; TEST FOR FUNCTION KEYS
EBC8 7204                               JB      K55                     ; NOT-LOWER-FUNCTION
EBCA B000                               MOV     AL,0                    ; SCAN CODE IN AH ALREADY
EBCC EB07                               JMP     SHORT K57               ; BUFFER_FILL
EBCE                            K55:                                    ; NOT-LOWER-FUNCTION
EBCE BBE1E8                             MOV     BX,OFFSET K10           ; LC TABLE

                                ;----- TRANSLATE THE CHARACTER

EBD1                            K56:                                    ; TRANSLATE-CHAR
EBD1 FEC8                               DEC     AL                      ; CONVERT ORIGIN
EBD3 2ED7                               XLAT    CS:K11                  ; CONVERT THE SCAN CODE TO ASCII

                                ;----- PUT CHARACTER INTO BUFFER

EBD5                            K57:                                    ; BUFFER-FILL
```

```
LOC OBJ                  SOURCE
EBD5 3CFF                       CMP     AL,-1                   ; IS THIS AN IGNORE CHAR
EBD7 741F                       JE      K59                     ; YES, DO NOTHING WITH IT
EBD9 80FCFF                     CMP     AH,-1                   ; LOOK FOR -1 PSEUDO SCAN
EBDC 741A                       JE      K59                     ; NEAR_INTERRUPT_RETURN
                        ;----- HANDLE THE CAPS LOCK PROBLEM
EBDE                    K58:                                    ; BUFFER-FILL-NOTEST
EBDE F606170040                 TEST    KB_FLAG,CAPS_STATE      ; ARE WE IN CAPS LOCK STATE
EBE3 7420                       JZ      K61                     ; SKIP IF NOT
                        ;----- IN CAPS LOCK STATE
EBE5 F606170003                 TEST    KB_FLAG,LEFT_SHIFT+RIGHT_SHIFT  ; TEST FOR SHIFT STATE
EBEA 740F                       JZ      K60                     ; IF NOT SHIFT, CONVERT LOWER TO UPPER
                        ;----- CONVERT ANY UPPER CASE TO LOWER CASE
EBEC 3C41                       CMP     AL,'A'                  ; FIND OUT IF ALPHABETIC
EBEE 7215                       JB      K61                     ; NOT_CAPS_STATE
EBF0 3C5A                       CMP     AL,'Z'
EBF2 7711                       JA      K61                     ; NOT_CAPS_STATE
EBF4 0420                       ADD     AL,'a'-'A'              ; CONVERT TO LOWER CASE
EBF6 EB0D                       JMP     SHORT K61               ; NOT_CAPS_STATE
EBF8                    K59:                                    ; NEAR-INTERRUPT-RETURN
EBF8 E95EFE                     JMP     K26                     ; INTERRUPT_RETURN
                        ;----- CONVERT ANY LOWER CASE TO UPPER CASE
EBFB                    K60:                                    ; LOWER-TO-UPPER
EBFB 3C61                       CMP     AL,'a'                  ; FIND OUT IF ALPHABETIC
EBFD 7206                       JB      K61                     ; NOT_CAPS_STATE
EBFF 3C7A                       CMP     AL,'z'
EC01 7702                       JA      K61                     ; NOT_CAPS_STATE
EC03 2C20                       SUB     AL,'a'-'A'              ; CONVERT TO UPPER CASE
EC05                    K61:                                    ; NOT-CAPS-STATE
EC05 8B1E1C00                   MOV     BX,BUFFER_TAIL          ; GET THE END POINTER TO THE BUFFER
EC09 8BF3                       MOV     SI,BX                   ; SAVE THE VALUE
EC0B E863FC                     CALL    K4                      ; ADVANCE THE TAIL
EC0E 3B1E1A00                   CMP     BX,BUFFER_HEAD          ; HAS THE BUFFER WRAPPED AROUND
EC12 7413                       JE      K62                     ; BUFFER_FULL_BEEP
EC14 8904                       MOV     [SI],AX                 ; STORE THE VALUE
EC16 891E1C00                   MOV     BUFFER_TAIL,BX          ; MOVE THE POINTER UP
EC1A E93CFE                     JMP     K26                     ; INTERRUPT_RETURN
                        ;----- TRANSLATE SCAN FOR PSEUDO SCAN CODES
EC1D                    K63:                                    ; TRANSLATE-SCAN
EC1D 2C3B                       SUB     AL,59                   ; CONVERT ORIGIN TO FUNCTION KEYS
EC1F                    K64:                                    ; TRANSLATE-SCAN-ORGD
EC1F 2ED7                       XLAT    CS:K9                   ; CTL TABLE SCAN
EC21 8AE0                       MOV     AH,AL                   ; PUT VALUE INTO AH
EC23 B000                       MOV     AL,0                    ; ZERO ASCII CODE
EC25 EBAE                       JMP     K57                     ; PUT IT INTO THE BUFFER
                        KB_INT  ENDP
                        ;----- BUFFER IS FULL, SOUND THE BEEPER
EC27                    K62:                                    ; BUFFER-FULL-BEEP
EC27 B020                       MOV     AL,EOI                  ; END OF INTERRUPT COMMAND
EC29 E620                       OUT     20H,AL                  ; SEND COMMAND TO INT CONTROL PORT
EC2B BB8000                     MOV     BX,080H                 ; NUMBER OF CYCLES FOR 1/12 SECOND TONE
EC2E E461                       IN      AL,KB_CTL               ; GET CONTROL INFORMATION
EC30 50                         PUSH    AX                      ; SAVE
EC31                    K65:                                    ; BEEP-CYCLE
EC31 24FC                       AND     AL,0FCH                 ; TURN OFF TIMER GATE AND SPEAKER DATA
EC33 E661                       OUT     KB_CTL,AL               ; OUTPUT TO CONTROL
EC35 B94800                     MOV     CX,48H                  ; HALF CYCLE TIME FOR TONE
EC38                    K66:
EC38 E2FE                       LOOP    K66                     ; SPEAKER OFF
EC3A 0C02                       OR      AL,2                    ; TURN ON SPEAKER BIT
EC3C E661                       OUT     KB_CTL,AL               ; OUTPUT TO CONTROL
EC3E B94800                     MOV     CX,48H                  ; SET UP COUNT
EC41                    K67:
EC41 E2FE                       LOOP    K67                     ; ANOTHER HALF CYCLE
EC43 4B                         DEC     BX                      ; TOTAL TIME COUNT
```

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LOC OBJ                 SOURCE

EC44 75EB                       JNZ     K65                     ; DO ANOTHER CYCLE
EC46 58                         POP     AX                      ; RECOVER CONTROL
EC47 E661                       OUT     KB_CTL,AL               ; OUTPUT THE CONTROL
EC49 E912FE                     JMP     K27
                        ;---------------------------------------
                        ;       ROS CHECKSUM SUBROUTINE        :
                        ;---------------------------------------
EC4C                    ROS_CHECKSUM    PROC    NEAR            ; NEXT_ROS_MODULE
EC4C B90020                     MOV     CX,8192                 ; NUMBER OF BYTES TO ADD
EC4F                    ROS_CHECKSUM_CNT:                       ; ENTRY FOR OPTIONAL ROS TEST
EC4F 32C0                       XOR     AL,AL
EC51                    C26:
EC51 0207                       ADD     AL,DS:[BX]
EC53 43                         INC     BX                      ; POINT TO NEXT BYTE
EC54 E2FB                       LOOP    C26                     ; ADD ALL BYTES IN ROS MODULE
EC56 0AC0                       OR      AL,AL                   ; SUM = 0?
EC58 C3                         RET
                        ROS_CHECKSUM    ENDP

                        ;-- INT 13 ----------------------------------------------------------
                        ; DISKETTE I/O                                                      :
                        ;       THIS INTERFACE PROVIDES ACCESS TO THE 5 1/4" DISKETTE DRIVES :
                        ; INPUT                                                             :
                        ;       (AH)=0  RESET DISKETTE SYSTEM                               :
                        ;               HARD RESET TO NEC, PREPARE COMMAND, RECAL REQUIRED  :
                        ;               ON ALL DRIVES                                       :
                        ;       (AH)=1  READ THE STATUS OF THE SYSTEM INTO (AL)             :
                        ;               DISKETTE_STATUS FROM LAST OPERATION IS USED         :
                        ;                                                                   :
                        ; REGISTERS FOR READ/WRITE/VERIFY/FORMAT                            :
                        ;       (DL) - DRIVE NUMBER (0-3 ALLOWED, VALUE CHECKED)            :
                        ;       (DH) - HEAD NUMBER (0-1 ALLOWED, NOT VALUE CHECKED)         :
                        ;       (CH) - TRACK NUMBER (0-39, NOT VALUE CHECKED)               :
                        ;       (CL) - SECTOR NUMBER (1-8, NOT VALUE CHECKED,               :
                        ;                               NOT USED FOR FORMAT)                :
                        ;       (AL) - NUMBER OF SECTORS ( MAX = 8, NOT VALUE CHECKED, NOT USED :
                        ;                                        FOR FORMAT)                :
                        ;       (ES:BX) - ADDRESS OF BUFFER ( NOT REQUIRED FOR VERIFY)      :
                        ;                                                                   :
                        ;       (AH)=2  READ THE DESIRED SECTORS INTO MEMORY                :
                        ;       (AH)=3  WRITE THE DESIRED SECTORS FROM MEMORY               :
                        ;       (AH)=4  VERIFY THE DESIRED SECTORS                          :
                        ;       (AH)=5  FORMAT THE DESIRED TRACK                            :
                        ;               FOR THE FORMAT OPERATION, THE BUFFER POINTER (ES,BX) :
                        ;               MUST POINT TO THE COLLECTION OF DESIRED ADDRESS FIELDS :
                        ;               FOR THE TRACK.  EACH FIELD IS COMPOSED OF 4 BYTES,  :
                        ;               (C,H,R,N), WHERE C = TRACK NUMBER, H=HEAD NUMBER,   :
                        ;               R = SECTOR NUMBER, N= NUMBER OF BYTES PER SECTOR    :
                        ;               (00=128, 01=256, 02=512, 03=1024).  THERE MUST BE ONE :
                        ;               ENTRY FOR EVERY SECTOR ON THE TRACK.  THIS INFORMATION :
                        ;               IS USED TO FIND THE REQUESTED SECTOR DURING READ/WRITE :
                        ;               ACCESS.                                             :
                        ;                                                                   :
                        ; DATA VARIABLE -- DISK_POINTER                                     :
                        ;       DOUBLE WORD POINTER TO THE CURRENT SET OF DISKETTE PARAMETERS :
                        ; OUTPUT                                                            :
                        ;       AH = STATUS OF OPERATION                                    :
                        ;               STATUS BITS ARE DEFINED IN THE EQUATES FOR          :
                        ;               DISKETTE_STATUS VARIABLE IN THE DATA SEGMENT OF THIS :
                        ;               MODULE.                                             :
                        ;       CY = 0  SUCCESSFUL OPERATION (AH=0 ON RETURN)               :
                        ;       CY = 1  FAILED OPERATION (AH HAS ERROR REASON)              :
                        ;       FOR READ/WRITE/VERIFY                                       :
                        ;               DS,BX,DX,CH,CL PRESERVED                            :
                        ;               AL = NUMBER OF SECTORS ACTUALLY READ                :
                        ;               ***** AL MAY NOT BE CORRECT IF TIME OUT ERROR OCCURS :
                        ;       NOTE:   IF AN ERROR IS REPORTED BY THE DISKETTE CODE, THE   :
                        ;               APPROPRIATE ACTION IS TO RESET THE DISKETTE, THEN RETRY :
                        ;               THE OPERATION. ON READ ACCESSES, NO MOTOR START DELAY :
                        ;               IS TAKEN, SO THAT THREE RETRIES ARE REQUIRED ON READS :
                        ;               TO ENSURE THAT THE PROBLEM IS NOT DUE TO MOTOR      :
                        ;               START-UP.                                           :
                        ;--------------------------------------------------------------------
                                ASSUME  CS:CODE,DS:DATA,ES:DATA
EC59                            ORG     0EC59H
EC59                    DISKETTE_IO     PROC    FAR
EC59 FB                         STI                             ; INTERRUPTS BACK ON
```

```
LOC OBJ            LINE    SOURCE

EC5A 53                            PUSH    BX                      ; SAVE ADDRESS
EC5B 51                            PUSH    CX
EC5C 1E                            PUSH    DS                      ; SAVE SEGMENT REGISTER VALUE
EC5D 56                            PUSH    SI                      ; SAVE ALL REGISTERS DURING OPERATION
EC5E 57                            PUSH    DI
EC5F 55                            PUSH    BP
EC60 52                            PUSH    DX
EC61 8BEC                          MOV     BP,SP                   ; SET UP POINTER TO HEAD PARM
EC63 E8D812                        CALL    DDS
EC66 E81C00                        CALL    J1                      ; CALL THE REST TO ENSURE DS RESTORED
EC69 BB0400                        MOV     BX,4                    ; GET THE MOTOR WAIT PARAMETER
EC6C E8FD01                        CALL    GET_PARM
EC6F 88264000                      MOV     MOTOR_COUNT,AH          ; SET THE TIMER COUNT FOR THE MOTOR
EC73 8A264100                      MOV     AH,DISKETTE_STATUS      ; GET STATUS OF OPERATION
EC77 80FC01                        CMP     AH,1                    ; SET THE CARRY FLAG TO INDICATE
EC7A F5                            CMC                             ;  SUCCESS OR FAILURE
EC7B 5A                            POP     DX                      ; RESTORE ALL REGISTERS
EC7C 5D                            POP     BP
EC7D 5F                            POP     DI
EC7E 5E                            POP     SI
EC7F 1F                            POP     DS
EC80 59                            POP     CX
EC81 5B                            POP     BX                      ; RECOVER ADDRESS
EC82 CA0200                        RET     2                       ; THROW AWAY SAVED FLAGS
                           DISKETTE_IO     ENDP

EC85                       J1      PROC    NEAR
EC85 8AF0                          MOV     DH,AL                   ; SAVE # SECTORS IN DH
EC87 80263F007F                    AND     MOTOR_STATUS,07FH       ; INDICATE A READ OPERATION
EC8C 0AE4                          OR      AH,AH                   ; AH=0
EC8E 7427                          JZ      DISK_RESET
EC90 FECC                          DEC     AH                      ; AH=1
EC92 7473                          JZ      DISK_STATUS
EC94 C606410000                    MOV     DISKETTE_STATUS,0       ; RESET THE STATUS INDICATOR
EC99 80FA04                        CMP     DL,4                    ; TEST FOR DRIVE IN 0-3 RANGE
EC9C 7313                          JAE     J3                      ; ERROR IF ABOVE
EC9E FECC                          DEC     AH                      ; AH=2
ECA0 7469                          JZ      DISK_READ
ECA2 FECC                          DEC     AH                      ; AH=3
ECA4 7503                          JNZ     J2                      ; TEST_DISK_VERF
ECA6 E99500                        JMP     DISK_WRITE
ECA9                       J2:                                     ; TEST_DISK_VERF
ECA9 FECC                          DEC     AH                      ; AH=4
ECAB 7467                          JZ      DISK_VERF
ECAD FECC                          DEC     AH                      ; AH=5
ECAF 7467                          JZ      DISK_FORMAT
ECB1                       J3:                                     ; BAD_COMMAND
ECB1 C606410001                    MOV     DISKETTE_STATUS,BAD_CMD ; ERROR CODE, NO SECTORS TRANSFERRED
ECB6 C3                            RET                             ; UNDEFINED OPERATION
                           J1      ENDP

                           ;----- RESET THE DISKETTE SYSTEM

ECB7                       DISK_RESET      PROC    NEAR
ECB7 BAF203                        MOV     DX,03F2H                ; ADAPTER CONTROL PORT
ECBA FA                            CLI                             ; NO INTERRUPTS
ECBB A03F00                        MOV     AL,MOTOR_STATUS         ; WHICH MOTOR IS ON
ECBE B104                          MOV     CL,4                    ; SHIFT COUNT
ECC0 D2E0                          SAL     AL,CL                   ; MOVE MOTOR VALUE TO HIGH NYBBLE
ECC2 A820                          TEST    AL, 20H                 ; SELECT CORRESPONDING DRIVE
ECC4 750C                          JNZ     J5                      ; JUMP IF MOTOR ONE IS ON
ECC6 A840                          TEST    AL, 40H
ECC8 7506                          JNZ     J4                      ; JUMP IF MOTOR TWO IS ON
ECCA A880                          TEST    AL, 80H
ECCC 7406                          JZ      J6                      ; JUMP IF MOTOR ZERO IS ON
ECCE FEC0                          INC     AL
ECD0                       J4:
ECD0 FEC0                          INC     AL
ECD2                       J5:
ECD2 FEC0                          INC     AL
ECD4                       J6:
ECD4 0C08                          OR      AL,8                    ; TURN ON INTERRUPT ENABLE
ECD6 EE                            OUT     DX,AL                   ; RESET THE ADAPTER
ECD7 C6063E0000                    MOV     SEEK_STATUS,0           ; SET RECAL REQUIRED ON ALL DRIVES
ECDC C606410000                    MOV     DISKETTE_STATUS,0       ; SET OK STATUS FOR DISKETTE
ECE1 0C04                          OR      AL,4                    ; TURN OFF RESET
ECE3 EE                            OUT     DX,AL                   ; TURN OFF THE RESET
```

Section 5

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LOC OBJ                 SOURCE

ECE4 FB                         STI                             ; REENABLE THE INTERRUPTS
ECE5 E82A02                     CALL    CHK_STAT_2              ; DO SENSE INTERRUPT STATUS
                                                                ;  FOLLOWING RESET
ECE8 A04200                     MOV     AL,NEC_STATUS           ; IGNORE ERROR RETURN AND DO OWN TEST
ECEB 3CC0                       CMP     AL,0C0H                 ; TEST FOR DRIVE READY TRANSITION
ECED 7406                       JZ      J7                      ; EVERYTHING OK
ECEF 800E410020                 OR      DISKETTE_STATUS,BAD_NEC ; SET ERROR CODE
ECF4 C3                         RET

                        ;----- SEND SPECIFY COMMAND TO NEC

ECF5                    J7:                                     ; DRIVE_READY
ECF5 B403                       MOV     AH,03H                  ; SPECIFY COMMAND
ECF7 E84701                     CALL    NEC_OUTPUT              ; OUTPUT THE COMMAND
ECFA BB0100                     MOV     BX,1                    ; FIRST BYTE PARM IN BLOCK
ECFD E86C01                     CALL    GET_PARM                ;  TO THE NEC CONTROLLER
ED00 BB0300                     MOV     BX,3                    ; SECOND BYTE PARM IN BLOCK
ED03 E86601                     CALL    GET_PARM                ;  TO THE NEC CONTROLLER
ED06                    J8:                                     ; RESET_RET
ED06 C3                         RET                             ; RETURN TO CALLER
                        DISK_RESET      ENDP

                        ;----- DISKETTE STATUS ROUTINE

ED07                    DISK_STATUS     PROC    NEAR
ED07 A04100                     MOV     AL,DISKETTE_STATUS
ED0A C3                         RET
                        DISK_STATUS     ENDP

                        ;----- DISKETTE READ

ED0B                    DISK_READ       PROC    NEAR
ED0B B046                       MOV     AL,046H                 ; READ COMMAND FOR DMA
ED0D                    J9:                                     ; DISK_READ_CONT
ED0D E8B801                     CALL    DMA_SETUP               ; SET UP THE DMA
ED10 B4E6                       MOV     AH,0E6H                 ; SET UP RD COMMAND FOR NEC CONTROLLER
ED12 EB36                       JMP     SHORT RW_OPN            ; GO DO THE OPERATION
                        DISK_READ       ENDP

                        ;----- DISKETTE VERIFY

ED14                    DISK_VERF       PROC    NEAR
ED14 B042                       MOV     AL,042H                 ; VERIFY COMMAND FOR DMA
ED16 EBF5                       JMP     J9                      ; DO AS IF DISK READ
                        DISK_VERF       ENDP

                        ;----- DISKETTE FORMAT

ED18                    DISK_FORMAT     PROC    NEAR
ED18 800E3F0080                 OR      MOTOR_STATUS,80H        ; INDICATE WRITE OPERATION
ED1D B04A                       MOV     AL,04AH                 ; WILL WRITE TO THE DISKETTE
ED1F E8A601                     CALL    DMA_SETUP               ; SET UP THE DMA
ED22 B44D                       MOV     AH,04DH                 ; ESTABLISH THE FORMAT COMMAND
ED24 EB24                       JMP     SHORT RW_OPN            ; DO THE OPERATION
ED26                    J10:                                    ; CONTINUATION OF RW_OPN FOR FMT
ED26 BB0700                     MOV     BX,7                    ; GET THE
ED29 E84001                     CALL    GET_PARM                ;  BYTES/SECTOR VALUE TO NEC
ED2C BB0900                     MOV     BX,9                    ; GET THE
ED2F E83A01                     CALL    GET_PARM                ;  SECTORS/TRACK VALUE TO NEC
ED32 BB0F00                     MOV     BX,15                   ; GET THE
ED35 E83401                     CALL    GET_PARM                ;  GAP LENGTH VALUE TO NEC
ED38 BB1100                     MOV     BX,17                   ; GET THE FILLER BYTE
ED3B E9AB00                     JMP     J16                     ;  TO THE CONTROLLER
                        DISK_FORMAT     ENDP

                        ;----- DISKETTE WRITE ROUTINE

ED3E                    DISK_WRITE      PROC    NEAR
ED3E 800E3F0080                 OR      MOTOR_STATUS,80H        ; INDICATE WRITE OPERATION
ED43 B04A                       MOV     AL,04AH                 ; DMA WRITE COMMAND
ED45 E88001                     CALL    DMA_SETUP
ED48 B4C5                       MOV     AH,0C5H                 ; NEC COMMAND TO WRITE TO DISKETTE
                        DISK_WRITE      ENDP

                        ;----- ALLOW WRITE ROUTINE TO FALL INTO RW_OPN

                        ;------------------------------------------------------------
```

```
LOC OBJ                 LINE    SOURCE

                                ; RW_OPN                                                        :
                                ;       THIS ROUTINE PERFORMS THE READ/WRITE/VERIFY OPERATION   :
                                ;---------------------------------------------------------------
ED4A                            RW_OPN  PROC    NEAR
ED4A 7308                               JNC     J11                     ; TEST FOR DMA ERROR
ED4C C606410009                         MOV     DISKETTE_STATUS,DMA_BOUNDARY    ; SET ERROR
ED51 B000                               MOV     AL,0                    ; NO SECTORS TRANSFERRED
ED53 C3                                 RET                             ; RETURN TO MAIN ROUTINE
ED54                            J11:                                    ; DO_RW_OPN
ED54 50                                 PUSH    AX                      ; SAVE THE COMMAND

                                ;----- TURN ON THE MOTOR AND SELECT THE DRIVE

ED55 51                                 PUSH    CX                      ; SAVE THE T/S PARMS
ED56 8ACA                               MOV     CL,DL                   ; GET DRIVE NUMBER AS SHIFT COUNT
ED58 B001                               MOV     AL,1                    ; MASK FOR DETERMINING MOTOR BIT
ED5A D2E0                               SAL     AL,CL                   ; SHIFT THE MASK BIT
ED5C FA                                 CLI                             ; NO INTERRUPTS WHILE DETERMINING
                                                                        ;  MOTOR STATUS
ED5D C6064000FF                         MOV     MOTOR_COUNT,0FFH        ; SET LARGE COUNT DURING OPERATION
ED62 84063F00                           TEST    AL,MOTOR_STATUS         ; TEST THAT MOTOR FOR OPERATING
ED66 7531                               JNZ     J14                     ; IF RUNNING, SKIP THE WAIT
ED68 80263F00F0                         AND     MOTOR_STATUS,0F0H       ; TURN OFF ALL MOTOR BITS
ED6D 08063F00                           OR      MOTOR_STATUS,AL         ; TURN ON THE CURRENT MOTOR
ED71 FB                                 STI                             ; INTERRUPTS BACK ON
ED72 B010                               MOV     AL,10H                  ; MASK BIT
ED74 D2E0                               SAL     AL,CL                   ; DEVELOP BIT MASK FOR MOTOR ENABLE
ED76 0AC2                               OR      AL,DL                   ; GET DRIVE SELECT BITS IN
ED78 0C0C                               OR      AL,0CH                  ; NO RESET, ENABLE DMA/INT
ED7A 52                                 PUSH    DX                      ; SAVE REG
ED7B BAF203                             MOV     DX,03F2H                ; CONTROL PORT ADDRESS
ED7E EE                                 OUT     DX,AL
ED7F 5A                                 POP     DX                      ; RECOVER REGISTERS

                                ;----- WAIT FOR MOTOR IF WRITE OPERATION

ED80 F6063F0080                         TEST    MOTOR_STATUS,80H        ; IS THIS A WRITE
ED85 7412                               JZ      J14                     ; NO, CONTINUE WITHOUT WAIT
ED87 BB1400                             MOV     BX,20                   ; GET THE MOTOR WAIT
ED8A E8DF00                             CALL    GET_PARM                ;  PARAMETER
ED8D 0AE4                               OR      AH,AH                   ; TEST FOR NO WAIT
ED8F                            J12:                                    ; TEST_WAIT_TIME
ED8F 7408                               JZ      J14                     ; EXIT WITH TIME EXPIRED
ED91 2BC9                               SUB     CX,CX                   ; SET UP 1/8 SECOND LOOP TIME
ED93                            J13:
ED93 E2FE                               LOOP    J13                     ; WAIT FOR THE REQUIRED TIME
ED95 FECC                               DEC     AH                      ; DECREMENT TIME VALUE
ED97 EBF6                               JMP     J12                     ; ARE WE DONE YET
ED99                            J14:                                    ; MOTOR_RUNNING
ED99 FB                                 STI                             ; INTERRUPTS BACK ON FOR BYPASS WAIT
ED9A 59                                 POP     CX

                                ;----- DO THE SEEK OPERATION

ED9B E8DF00                             CALL    SEEK                    ; MOVE TO CORRECT TRACK
ED9E 58                                 POP     AX                      ; RECOVER COMMAND
ED9F 8AFC                               MOV     BH,AH                   ; SAVE COMMAND IN BH
EDA1 B600                               MOV     DH,0                    ; SET NO SECTORS READ IN CASE OF ERROR
EDA3 724B                               JC      J17                     ; IF ERROR, THEN EXIT AFTER MOTOR OFF
EDA5 BEF0ED90                           MOV     SI,OFFSET J17           ; DUMMY RETURN ON STACK FOR NEC_OUTPUT
EDA9 56                                 PUSH    SI                      ;  SO THAT IT WILL RETURN TO MOTOR OFF
                                                                        ;  LOCATION

                                ;----- SEND OUT THE PARAMETERS TO THE CONTROLLER

EDAA E89400                             CALL    NEC_OUTPUT              ; OUTPUT THE OPERATION COMMAND
EDAD 8A6601                             MOV     AH,[BP+1]               ; GET THE CURRENT HEAD NUMBER
EDB0 D0E4                               SAL     AH,1                    ; MOVE IT TO BIT 2
EDB2 D0E4                               SAL     AH,1
EDB4 80E404                             AND     AH,4                    ; ISOLATE THAT BIT
EDB7 0AE2                               OR      AH,DL                   ; OR IN THE DRIVE NUMBER
EDB9 E88500                             CALL    NEC_OUTPUT

                                ;----- TEST FOR FORMAT COMMAND

EDBC 80FF4D                             CMP     BH,04DH                 ; IS THIS A FORMAT OPERATION
EDBF 7503                               JNE     J15                     ; NO, CONTINUE WITH R/W/V
```

Section 5

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LOC OBJ                 SOURCE

EDC1 E962FF                     JMP     J10                     ; IF SO, HANDLE SPECIAL
EDC4                    J15:
EDC4 8AE5                       MOV     AH,CH                   ; CYLINDER NUMBER
EDC6 E87800                     CALL    NEC_OUTPUT
EDC9 8A6601                     MOV     AH,[BP+1]               ; HEAD NUMBER FROM STACK
EDCC E87200                     CALL    NEC_OUTPUT
EDCF 8AE1                       MOV     AH,CL                   ; SECTOR NUMBER
EDD1 E86D00                     CALL    NEC_OUTPUT
EDD4 BB0700                     MOV     BX,7                    ; BYTES/SECTOR PARM FROM BLOCK
EDD7 E89200                     CALL    GET_PARM                ;  TO THE NEC
EDDA BB0900                     MOV     BX,9                    ; EOT PARM FROM BLOCK
EDDD E88C00                     CALL    GET_PARM                ;  TO THE NEC
EDE0 BB0B00                     MOV     BX,11                   ; GAP LENGTH PARM FROM BLOCK
EDE3 E88600                     CALL    GET_PARM                ;  TO THE NEC
EDE6 BB0D00                     MOV     BX,13                   ; DTL PARM FROM BLOCK
EDE9                    J16:                                    ; RW_OPN_FINISH
EDE9 E88000                     CALL    GET_PARM                ;  TO THE NEC
EDEC 5E                         POP     SI                      ; CAN NOW DISCARD THAT DUMMY
                                                                ;  RETURN ADDRESS

                        ;----- LET THE OPERATION HAPPEN

EDED E84301                     CALL    WAIT_INT                ; WAIT FOR THE INTERRUPT
EDF0                    J17:                                    ; MOTOR_OFF
EDF0 7245                       JC      J21                     ; LOOK FOR ERROR
EDF2 E87401                     CALL    RESULTS                 ; GET THE NEC STATUS
EDF5 723F                       JC      J20                     ; LOOK FOR ERROR

                        ;----- CHECK THE RESULTS RETURNED BY THE CONTROLLER

EDF7 FC                         CLD                             ; SET THE CORRECT DIRECTION
EDF8 BE4200                     MOV     SI,OFFSET NEC_STATUS    ; POINT TO STATUS FIELD
EDFB AC                         LODS    NEC_STATUS              ; GET ST0
EDFC 24C0                       AND     AL,0C0H                 ; TEST FOR NORMAL TERMINATION
EDFE 743B                       JZ      J22                     ; OPN_OK
EE00 3C40                       CMP     AL,040H                 ; TEST FOR ABNORMAL TERMINATION
EE02 7529                       JNZ     J18                     ; NOT ABNORMAL, BAD NEC

                        ;----- ABNORMAL TERMINATION, FIND OUT WHY

EE04 AC                         LODS    NEC_STATUS              ; GET ST1
EE05 D0E0                       SAL     AL,1                    ; TEST FOR EOT FOUND
EE07 B404                       MOV     AH,RECORD_NOT_FND
EE09 7224                       JC      J19                     ; RW_FAIL
EE0B D0E0                       SAL     AL,1
EE0D D0E0                       SAL     AL,1                    ; TEST FOR CRC ERROR
EE0F B410                       MOV     AH,BAD_CRC
EE11 721C                       JC      J19                     ; RW_FAIL
EE13 D0E0                       SAL     AL,1                    ; TEST FOR DMA OVERRUN
EE15 B408                       MOV     AH,BAD_DMA
EE17 7216                       JC      J19                     ; RW_FAIL
EE19 D0E0                       SAL     AL,1
EE1B D0E0                       SAL     AL,1                    ; TEST FOR RECORD NOT FOUND
EE1D B404                       MOV     AH,RECORD_NOT_FND
EE1F 720E                       JC      J19                     ; RW_FAIL
EE21 D0E0                       SAL     AL,1
EE23 B403                       MOV     AH,WRITE_PROTECT        ; TEST FOR WRITE_PROTECT
EE25 7208                       JC      J19                     ; RW_FAIL
EE27 D0E0                       SAL     AL,1                    ; TEST MISSING ADDRESS MARK
EE29 B402                       MOV     AH,BAD_ADDR_MARK
EE2B 7202                       JC      J19                     ; RW_FAIL

                        ;----- NEC MUST HAVE FAILED

EE2D                    J18:                                    ; RW-NEC-FAIL
EE2D B420                       MOV     AH,BAD_NEC
EE2F                    J19:                                    ; RW-FAIL
EE2F 08264100                   OR      DISKETTE_STATUS,AH
EE33 E87801                     CALL    NUM_TRANS               ; HOW MANY WERE REALLY TRANSFERRED
EE36                    J20:                                    ; RW_ERR
EE36 C3                         RET                             ; RETURN TO CALLER
EE37                    J21:                                    ; RW_ERR_RES
EE37 E82F01                     CALL    RESULTS                 ; FLUSH THE RESULTS BUFFER
EE3A C3                         RET

                        ;----- OPERATION WAS SUCCESSFUL

```

```
LOC OBJ          LINE   SOURCE

EE3B                    J22:                                    ; OPN_OK
EE3B E87001                     CALL    NUM_TRANS               ; HOW MANY GOT MOVED
EE3E 32E4                       XOR     AH,AH                   ; NO ERRORS
EE40 C3                         RET
                        RW_OPN  ENDP
                        ;--------------------------------------------------------------------
                        ; NEC_OUTPUT                                                        :
                        ;       THIS ROUTINE SENDS A BYTE TO THE NEC CONTROLLER AFTER TESTING   :
                        ;       FOR CORRECT DIRECTION AND CONTROLLER READY THIS ROUTINE WILL    :
                        ;       TIME OUT IF THE BYTE IS NOT ACCEPTED WITHIN A REASONABLE        :
                        ;       AMOUNT OF TIME, SETTING THE DISKETTE STATUS ON COMPLETION.      :
                        ; INPUT                                                             :
                        ;       (AH)    BYTE TO BE OUTPUT                                   :
                        ; OUTPUT                                                            :
                        ;       CY = 0  SUCCESS                                             :
                        ;       CY = 1  FAILURE -- DISKETTE STATUS UPDATED                  :
                        ;               IF A FAILURE HAS OCCURRED, THE RETURN IS MADE ONE LEVEL :
                        ;               HIGHER THAN THE CALLER OF NEC_OUTPUT.               :
                        ;               THIS REMOVES THE REQUIREMENT OF TESTING AFTER EVERY :
                        ;               CALL OF NEC_OUTPUT.                                 :
                        ;       (AL) DESTROYED                                              :
                        ;--------------------------------------------------------------------
EE41                    NEC_OUTPUT      PROC    NEAR
EE41 52                         PUSH    DX                      ; SAVE REGISTERS
EE42 51                         PUSH    CX
EE43 BAF403                     MOV     DX,03F4H                ; STATUS PORT
EE46 33C9                       XOR     CX,CX                   ; COUNT FOR TIME OUT
EE48                    J23:
EE48 EC                         IN      AL,DX                   ; GET STATUS
EE49 A840                       TEST    AL,040H                 ; TEST DIRECTION BIT
EE4B 740C                       JZ      J25                     ; DIRECTION OK
EE4D E2F9                       LOOP    J23
EE4F                    J24:                                    ; TIME_ERROR
EE4F 800E410080                 OR      DISKETTE_STATUS,TIME_OUT
EE54 59                         POP     CX
EE55 5A                         POP     DX                      ; SET ERROR CODE AND RESTORE REGS
EE56 58                         POP     AX                      ; DISCARD THE RETURN ADDRESS
EE57 F9                         STC                             ; INDICATE ERROR TO CALLER
EE58 C3                         RET
EE59                    J25:
EE59 33C9                       XOR     CX,CX                   ; RESET THE COUNT
EE5B                    J26:
EE5B EC                         IN      AL,DX                   ; GET THE STATUS
EE5C A880                       TEST    AL,080H                 ; IS IT READY
EE5E 7504                       JNZ     J27                     ; YES, GO OUTPUT
EE60 E2F9                       LOOP    J26                     ; COUNT DOWN AND TRY AGAIN
EE62 EBEB                       JMP     J24                     ; ERROR CONDITION
EE64                    J27:                                    ; OUTPUT
EE64 8AC4                       MOV     AL,AH                   ; GET BYTE TO OUTPUT
EE66 B2F5                       MOV     DL,0F5H                 ; DATA PORT (3F5)
EE68 EE                         OUT     DX,AL                   ; OUTPUT THE BYTE
EE69 59                         POP     CX                      ; RECOVER REGISTERS
EE6A 5A                         POP     DX
EE6B C3                         RET                             ; CY = 0 FROM TEST INSTRUCTION
                        NEC_OUTPUT      ENDP
                        ;--------------------------------------------------------------------
                        ; GET_PARM                                                          :
                        ;       THIS ROUTINE FETCHES THE INDEXED POINTER FROM THE DISK_BASE     :
                        ;       BLOCK POINTED AT BY THE DATA VARIABLE DISK_POINTER. A BYTE FROM :
                        ;       THAT TABLE IS THEN MOVED INTO AH, THE INDEX OF THAT BYTE BEING  :
                        ;       THE PARM IN BX                                              :
                        ; ENTRY --                                                          :
                        ;   BX = INDEX OF BYTE TO BE FETCHED * 2                            :
                        ;       IF THE LOW BIT OF BX IS ON, THE BYTE IS IMMEDIATELY OUTPUT  :
                        ;       TO THE NEC CONTROLLER                                       :
                        ; EXIT --                                                           :
                        ;   AH = THAT BYTE FROM BLOCK                                       :
                        ;--------------------------------------------------------------------
EE6C                    GET_PARM        PROC    NEAR
EE6C 1E                         PUSH    DS                      ; SAVE SEGMENT
EE6D 2BC0                       SUB     AX,AX                   ; ZERO TO AX
EE6F 8ED8                       MOV     DS,AX
                                ASSUME  DS:ABS0
EE71 C5367800                   LDS     SI,DISK_POINTER         ; POINT TO BLOCK
EE75 D1EB                       SHR     BX,1                    ; DIVIDE BX BY 2, AND SET FLAG
                                                                ;  FOR EXIT
EE77 8A20                       MOV     AH,[SI+BX]              ; GET THE WORD
```

```
LOC OBJ          SOURCE

EE79 1F                  POP     DS                      ; RESTORE SEGMENT
                         ASSUME  DS:DATA
EE7A 72C5                JC      NEC_OUTPUT              ; IF FLAG SET, OUTPUT TO CONTROLLER
EE7C C3                  RET                             ; RETURN TO CALLER
                 GET_PARM        ENDP
                 ;----------------------------------------------------------------------
                 ; SEEK                                                                :
                 ;       THIS ROUTINE WILL MOVE THE HEAD ON THE NAMED DRIVE TO THE     :
                 ;       NAMED TRACK.  IF THE DRIVE HAS NOT BEEN ACCESSED SINCE THE    :
                 ;       DRIVE RESET COMMAND WAS ISSUED, THE DRIVE WILL BE RECALIBRATED. :
                 ; INPUT                                                               :
                 ;       (DL) = DRIVE TO SEEK ON                                       :
                 ;       (CH) = TRACK TO SEEK TO                                       :
                 ; OUTPUT                                                              :
                 ;       CY = 0 SUCCESS                                                :
                 ;       CY = 1 FAILURE -- DISKETTE_STATUS SET ACCORDINGLY             :
                 ;       (AX) DESTROYED                                                :
                 ;----------------------------------------------------------------------
EE7D             SEEK    PROC    NEAR
EE7D B001                MOV     AL,1                    ; ESTABLISH MASK FOR RECAL TEST
EE7F 51                  PUSH    CX                      ; SAVE INPUT VALUES
EE80 8ACA                MOV     CL,DL                   ; GET DRIVE VALUE INTO CL
EE82 D2C0                ROL     AL,CL                   ; SHIFT IT BY THE DRIVE VALUE
EE84 59                  POP     CX                      ; RECOVER TRACK VALUE
EE85 84063E00            TEST    AL,SEEK_STATUS          ; TEST FOR RECAL REQUIRED
EE89 7513                JNZ     J28                     ; NO_RECAL
EE8B 08063E00            OR      SEEK_STATUS,AL          ; TURN ON THE NO RECAL BIT IN FLAG
EE8F B407                MOV     AH,07H                  ; RECALIBRATE COMMAND
EE91 E8ADFF              CALL    NEC_OUTPUT
EE94 8AE2                MOV     AH,DL
EE96 E8A8FF              CALL    NEC_OUTPUT              ; OUTPUT THE DRIVE NUMBER
EE99 E87600              CALL    CHK_STAT_2              ; GET THE INTERUPT AND SENSE INT STATUS
EE9C 7229                JC      J32                     ; SEEK_ERROR

                 ;----- DRIVE IS IN SYNCH WITH CONTROLLER, SEEK TO TRACK

EE9E             J28:
EE9E B40F                MOV     AH,0FH                  ; SEEK COMMAND TO NEC
EEA0 E89EFF              CALL    NEC_OUTPUT
EEA3 8AE2                MOV     AH,DL                   ; DRIVE NUMBER
EEA5 E899FF              CALL    NEC_OUTPUT
EEA8 8AE5                MOV     AH,CH                   ; TRACK NUMBER
EEAA E894FF              CALL    NEC_OUTPUT
EEAD E86200              CALL    CHK_STAT_2              ; GET ENDING INTERRUPT AND
                                                         ;  SENSE STATUS

                 ;----- WAIT FOR HEAD SETTLE

EEB0 9C                  PUSHF                           ; SAVE STATUS FLAGS
EEB1 BB1200              MOV     BX,18                   ; GET HEAD SETTLE PARAMETER
EEB4 E8B5FF              CALL    GET_PARM
EEB7 51                  PUSH    CX                      ; SAVE REGISTER
EEB8             J29:                                    ; HEAD_SETTLE
EEB8 B92602              MOV     CX,550                  ; 1 MS LOOP
EEBB 0AE4                OR      AH,AH                   ; TEST FOR TIME EXPIRED
EEBD 7406                JZ      J31
EEBF             J30:
EEBF E2FE                LOOP    J30                     ; DELAY FOR 1 MS
EEC1 FECC                DEC     AH                      ; DECREMENT THE COUNT
EEC3 EBF3                JMP     J29                     ; DO IT SOME MORE
EEC5             J31:
EEC5 59                  POP     CX                      ; RECOVER STATE
EEC6 9D                  POPF
EEC7             J32:                                    ; SEEK_ERROR
EEC7 C3                  RET                             ; RETURN TO CALLER
                 SEEK    ENDP
                 ;----------------------------------------------------------------------
                 ; DMA_SETUP                                                           :
                 ;       THIS ROUTINE SETS UP THE DMA FOR READ/WRITE/VERIFY OPERATIONS.  :
                 ; INPUT                                                               :
                 ;       (AL) = MODE BYTE FOR THE DMA                                  :
                 ;       (ES:BX) - ADDRESS TO READ/WRITE THE DATA                      :
                 ; OUTPUT                                                              :
                 ;       (AX) DESTROYED                                                :
                 ;----------------------------------------------------------------------
EEC8             DMA_SETUP       PROC    NEAR
EEC8 51                  PUSH    CX                      ; SAVE THE REGISTER
```

```
LOC OBJ                LINE     SOURCE

EEC9 FA                        CLI                          ; NO MORE INTERRUPTS
EECA E60C                      OUT     DMA+12,AL            ; SET THE FIRST/LAST F/F
EECC 50                        PUSH    AX
EECD 58                        POP     AX
EECE E60B                      OUT     DMA+11,AL            ; OUTPUT THE MODE BYTE
EED0 8CC0                      MOV     AX,ES                ; GET THE ES VALUE
EED2 B104                      MOV     CL,4                 ; SHIFT COUNT
EED4 D3C0                      ROL     AX,CL                ; ROTATE LEFT
EED6 8AE8                      MOV     CH,AL                ; GET HIGHEST NYBLE OF ES TO CH
EED8 24F0                      AND     AL,0F0H              ; ZERO THE LOW NYBBLE FROM SEGMENT
EEDA 03C3                      ADD     AX,BX                ; TEST FOR CARRY FROM ADDITION
EEDC 7302                      JNC     J33
EEDE FEC5                      INC     CH                   ; CARRY MEANS HIGH 4 BITS MUST BE INC
EEE0                   J33:
EEE0 50                        PUSH    AX                   ; SAVE START ADDRESS
EEE1 E604                      OUT     DMA+4,AL             ; OUTPUT LOW ADDRESS
EEE3 8AC4                      MOV     AL,AH
EEE5 E604                      OUT     DMA+4,AL             ; OUTPUT HIGH ADDRESS
EEE7 8AC5                      MOV     AL,CH                ; GET HIGH 4 BITS
EEE9 240F                      AND     AL,0FH
EEEB E681                      OUT     081H,AL              ; OUTPUT THE HIGH 4 BITS TO
                                                            ;  THE PAGE REGISTER

                       ;----- DETERMINE COUNT

EEED 8AE6                      MOV     AH,DH                ; NUMBER OF SECTORS
EEEF 2AC0                      SUB     AL,AL                ;  TIMES 256 INTO AX
EEF1 D1E8                      SHR     AX,1                 ; SECTORS * 128 INTO AX
EEF3 50                        PUSH    AX
EEF4 BB0600                    MOV     BX,6                 ; GET THE BYTES/SECTOR PARM
EEF7 E872FF                    CALL    GET_PARM
EEFA 8ACC                      MOV     CL,AH                ; USE AS SHIFT COUNT (0=128, 1=256 ETC)
EEFC 58                        POP     AX
EEFD D3E0                      SHL     AX,CL                ; MULTIPLY BY CORRECT AMOUNT
EEFF 48                        DEC     AX                   ; -1 FOR DMA VALUE
EF00 50                        PUSH    AX                   ; SAVE COUNT VALUE
EF01 E605                      OUT     DMA+5,AL             ; LOW BYTE OF COUNT
EF03 8AC4                      MOV     AL,AH
EF05 E605                      OUT     DMA+5,AL             ; HIGH BYTE OF COUNT
EF07 FB                        STI                          ; INTERRUPTS BACK ON
EF08 59                        POP     CX                   ; RECOVER COUNT VALUE
EF09 58                        POP     AX                   ; RECOVER ADDRESS VALUE
EF0A 03C1                      ADD     AX,CX                ; ADD, TEST FOR 64K OVERFLOW
EF0C 59                        POP     CX                   ; RECOVER REGISTER
EF0D B002                      MOV     AL,2                 ; MODE FOR 8237
EF0F E60A                      OUT     DMA+10,AL            ; INITIALIZE THE DISKETTE CHANNEL
EF11 C3                        RET                          ; RETURN TO CALLER,
                                                            ;  CFL SET BY ABOVE IF ERROR
                       DMA_SETUP       ENDP
                       ;----------------------------------------------------------------------
                       ; CHK_STAT_2                                                           :
                       ;       THIS ROUTINE HANDLES THE INTERRUPT RECEIVED AFTER A             :
                       ;       RECALIBRATE, SEEK, OR RESET TO THE ADAPTER.                     :
                       ;       THE INTERRUPT IS WAITED FOR, THE INTERRUPT STATUS SENSED,       :
                       ;       AND THE RESULT RETURNED TO THE CALLER.                          :
                       ; INPUT                                                                :
                       ;       NONE                                                           :
                       ; OUTPUT                                                               :
                       ;       CY = 0 SUCCESS                                                 :
                       ;       CY = 1 FAILURE -- ERROR IS IN DISKETTE_STATUS                  :
                       ;       (AX) DESTROYED                                                 :
                       ;----------------------------------------------------------------------
EF12                   CHK_STAT_2      PROC    NEAR
EF12 E81E00                    CALL    WAIT_INT             ; WAIT FOR THE INTERRUPT
EF15 7214                      JC      J34                  ; IF ERROR, RETURN IT
EF17 B408                      MOV     AH,08H               ; SENSE INTERRUPT STATUS COMMAND
EF19 E825FF                    CALL    NEC_OUTPUT
EF1C E84A00                    CALL    RESULTS              ; READ IN THE RESULTS
EF1F 720A                      JC      J34                  ; CHK2_RETURN
EF21 A04200                    MOV     AL,NEC_STATUS        ; GET THE FIRST STATUS BYTE
EF24 2460                      AND     AL,060H              ; ISOLATE THE BITS
EF26 3C60                      CMP     AL,060H              ; TEST FOR CORRECT VALUE
EF28 7402                      JZ      J35                  ; IF ERROR, GO MARK IT
EF2A F8                        CLC                          ; GOOD RETURN
EF2B                   J34:
EF2B C3                        RET                          ; RETURN TO CALLER
EF2C                   J35:                                 ; CHK2_ERROR
```

```
LOC OBJ                 LINE    SOURCE

EF2C 800E410040                         OR      DISKETTE_STATUS,BAD_SEEK
EF31 F9                                 STC                             ; ERROR RETURN CODE
EF32 C3                                 RET
                                CHK_STAT_2      ENDP
                                ;----------------------------------------------------------------
                                ; WAIT INT                                                      :
                                ;       THIS ROUTINE WAITS FOR AN INTERRUPT TO OCCUR. A TIME OUT :
                                ;       ROUTINE TAKES PLACE DURING THE WAIT, SO THAT AN ERROR MAY BE :
                                ;       RETURNED IF THE DRIVE IS NOT READY.                     :
                                ; INPUT                                                         :
                                ;       NONE                                                    :
                                ; OUTPUT                                                        :
                                ;       CY = 0 SUCCESS                                          :
                                ;       CY = 1 FAILURE -- DISKETTE_STATUS IS SET ACCORDINGLY    :
                                ;       (AX) DESTROYED                                          :
                                ;----------------------------------------------------------------
EF33                            WAIT_INT        PROC    NEAR
EF33 FB                                 STI                             ; TURN ON INTERRUPTS, JUST IN CASE
EF34 53                                 PUSH    BX
EF35 51                                 PUSH    CX                      ; SAVE REGISTERS
EF36 B302                               MOV     BL,2                    ; CLEAR THE COUNTERS
EF38 33C9                               XOR     CX,CX                   ; FOR 2 SECOND WAIT
EF3A                            J36:
EF3A F6063E0080                         TEST    SEEK_STATUS,INT_FLAG    ; TEST FOR INTERRUPT OCCURRING
EF3F 750C                               JNZ     J37
EF41 E2F7                               LOOP    J36                     ; COUNT DOWN WHILE WAITING
EF43 FECB                               DEC     BL                      ; SECOND LEVEL COUNTER
EF45 75F3                               JNZ     J36
EF47 800E410080                         OR      DISKETTE_STATUS,TIME_OUT        ; NOTHING HAPPENED
EF4C F9                                 STC                             ; ERROR RETURN
EF4D                            J37:
EF4D 9C                                 PUSHF                           ; SAVE CURRENT CARRY
EF4E 80263E007F                         AND     SEEK_STATUS,NOT INT_FLAG        ; TURN OFF INTERRUPT FLAG
EF53 9D                                 POPF                            ; RECOVER CARRY
EF54 59                                 POP     CX
EF55 5B                                 POP     BX                      ; RECOVER REGISTERS
EF56 C3                                 RET                             ; GOOD RETURN CODE COMES
                                                                        ;  FROM TEST INST
                                WAIT_INT        ENDP
                                ;-----------------------------------------------------
                                ; DISK_INT                                          :
                                ;       THIS ROUTINE HANDLES THE DISKETTE INTERRUPT :
                                ;INPUT                                              :
                                ;       NONE                                        :
                                ; OUTPUT                                            :
                                ;       THE INTERRUPT FLAG IS SET IS SEEK_STATUS    :
                                ;-----------------------------------------------------
EF57                                    ORG     0EF57H
EF57                            DISK_INT        PROC    FAR
EF57 FB                                 STI                             ; RE ENABLE INTERRUPTS
EF58 1E                                 PUSH    DS
EF59 50                                 PUSH    AX
EF5A E8E10F                             CALL    DDS
EF5D 800E3E0080                         OR      SEEK_STATUS,INT_FLAG
EF62 B020                               MOV     AL,20H                  ; END OF INTERRUPT MARKER
EF64 E620                               OUT     20H,AL                  ; INTERRUPT CONTROL PORT
EF66 58                                 POP     AX
EF67 1F                                 POP     DS                      ; RECOVER SYSTEM
EF68 CF                                 IRET                            ; RETURN FROM INTERRUPT
                                DISK_INT        ENDP
                                ;----------------------------------------------------------------
                                ; RESULTS                                                       :
                                ;       THIS ROUTINE WILL READ ANYTHING THAT THE NEC CONTROLLER HAS :
                                ;       TO SAY FOLLOWING AN INTERRUPT.                          :
                                ; INPUT                                                         :
                                ;       NONE                                                    :
                                ; OUTPUT                                                        :
                                ;       CY = 0  SUCCESSFUL TRANSFER                             :
                                ;       CY = 1  FAILURE -- TIME OUT IN WAITING FOR STATUS       :
                                ;       NEC_STATUS AREA HAS STATUS BYTE LOADED INTO IT          :
                                ;       (AH) DESTROYED                                          :
                                ;----------------------------------------------------------------
EF69                            RESULTS PROC    NEAR
EF69 FC                                 CLD
EF6A BF4200                             MOV     DI,OFFSET NEC_STATUS    ; POINTER TO DATA AREA
EF6D 51                                 PUSH    CX                      ; SAVE COUNTER
EF6E 52                                 PUSH    DX
```

```
LOC OBJ                  SOURCE

EF6F 53                          PUSH    BX
EF70 B307                        MOV     BL,7                    ; MAX STATUS BYTES

                         ;----- WAIT FOR REQUEST FOR MASTER

EF72                     J38:                                    ; INPUT_LOOP
EF72 33C9                        XOR     CX,CX                   ; COUNTER
EF74 BAF403                      MOV     DX,03F4H                ; STATUS PORT
EF77                     J39:                                    ; WAIT FOR MASTER
EF77 EC                          IN      AL,DX                   ; GET STATUS
EF78 A880                        TEST    AL,080H                 ; MASTER READY
EF7A 750C                        JNZ     J40A                    ; TEST_DIR
EF7C E2F9                        LOOP    J39                     ; WAIT_MASTER
EF7E 800E410080                  OR      DISKETTE_STATUS,TIME_OUT
EF83                     J40:                                    ; RESULTS_ERROR
EF83 F9                          STC                             ; SET ERROR RETURN
EF84 5B                          POP     BX
EF85 5A                          POP     DX
EF86 59                          POP     CX
EF87 C3                          RET

                         ;----- TEST THE DIRECTION BIT

EF88                     J40A:
EF88 EC                          IN      AL,DX                   ; GET STATUS REG AGAIN
EF89 A840                        TEST    AL,040H                 ; TEST DIRECTION BIT
EF8B 7507                        JNZ     J42                     ; OK TO READ STATUS
EF8D                     J41:                                    ; NEC_FAIL
EF8D 800E410020                  OR      DISKETTE_STATUS,BAD_NEC
EF92 EBEF                        JMP     J40                     ; RESULTS_ERROR

                         ;----- READ IN THE STATUS

EF94                     J42:                                    ; INPUT_STAT
EF94 42                          INC     DX                      ; POINT AT DATA PORT
EF95 EC                          IN      AL,DX                   ; GET THE DATA
EF96 8805                        MOV     [DI],AL                 ; STORE THE BYTE
EF98 47                          INC     DI                      ; INCREMENT THE POINTER
EF99 B90A00                      MOV     CX,10                   ; LOOP TO KILL TIME FOR NEC
EF9C E2FE                J43:    LOOP    J43
EF9E 4A                          DEC     DX                      ; POINT AT STATUS PORT
EF9F EC                          IN      AL,DX                   ; GET STATUS
EFA0 A810                        TEST    AL,010H                 ; TEST FOR NEC STILL BUSY
EFA2 7406                        JZ      J44                     ; RESULTS DONE
EFA4 FECB                        DEC     BL                      ; DECREMENT THE STATUS COUNTER
EFA6 75CA                        JNZ     J38                     ; GO BACK FOR MORE
EFA8 EBE3                        JMP     J41                     ; CHIP HAS FAILED

                         ;----- RESULT OPERATION IS DONE

EFAA                     J44:
EFAA 5B                          POP     BX
EFAB 5A                          POP     DX
EFAC 59                          POP     CX                      ; RECOVER REGISTERS
EFAD C3                          RET                             ; GOOD RETURN CODE FROM TEST INST
                         ;--------------------------------------------------------------
                         ; NUM_TRANS                                                    :
                         ;       THIS ROUTINE CALCULATES THE NUMBER OF SECTORS THAT     :
                         ;       WERE ACTUALLY TRANSFERRED TO/FROM THE DISKETTE         :
                         ; INPUT                                                        :
                         ;       (CH) = CYLINDER OF OPERATION                           :
                         ;       (CL) = START SECTOR OF OPERATION                       :
                         ; OUTPUT                                                       :
                         ;       (AL) = NUMBER ACTUALLY TRANSFERRED                     :
                         ;       NO OTHER REGISTERS MODIFIED                            :
                         ;--------------------------------------------------------------
EFAE                     NUM_TRANS       PROC    NEAR
EFAE A04500                      MOV     AL,NEC_STATUS+3         ; GET CYLINDER ENDED UP ON
EFB1 3AC5                        CMP     AL,CH                   ; SAME AS WE STARTED
EFB3 A04700                      MOV     AL,NEC_STATUS+5         ; GET ENDING SECTOR
EFB6 740A                        JZ      J45                     ; IF ON SAME CYL, THEN NO ADJUST
EFB8 BB0800                      MOV     BX,8
EFBB E8AEFE                      CALL    GET_PARM                ; GET EOT VALUE
EFBE 8AC4                        MOV     AL,AH                   ;  INTO AL
EFC0 FEC0                        INC     AL                      ; USE EOT+1 FOR CALCULATION
EFC2                     J45:
EFC2 2AC1                        SUB     AL,CL                   ; SUBTRACT START FROM END
```

Section 5

```
LOC OBJ                 SOURCE

EFC4 C3                         RET
                        NUM_TRANS       ENDP
                        RESULTS ENDP
                        ;--------------------------------------------------------------------
                        ; DISK_BASE                                                          :
                        ;       THIS IS THE SET OF PARAMETERS REQUIRED FOR DISKETTE OPERATION.  :
                        ;       THEY ARE POINTED AT BY THE DATA VARIABLE DISK_POINTER. TO    :
                        ;       MODIFY THE PARAMETERS, BUILD ANOTHER PARAMETER BLOCK AND POINT  :
                        ;       DISK_POINTER TO IT.                                          :
                        ;--------------------------------------------------------------------
EFC7                            ORG     0EFC7H
EFC7                    DISK_BASE       LABEL   BYTE
EFC7 CF                         DB      11001111B       ; SRT=C, HD UNLOAD=0F - 1ST SPECIFY BYTE
EFC8 02                         DB      2               ; HD LOAD=1, MODE=DMA - 2ND SPECIFY BYTE
EFC9 25                         DB      MOTOR_WAIT      ; WAIT AFTER OPN TIL MOTOR OFF
EFCA 02                         DB      2               ; 512 BYTES/SECTOR
EFCB 08                         DB      8               ; EOT ( LAST SECTOR ON TRACK)
EFCC 2A                         DB      02AH            ; GAP LENGTH
EFCD FF                         DB      0FFH            ; DTL
EFCE 50                         DB      050H            ; GAP LENGTH FOR FORMAT
EFCF F6                         DB      0F6H            ; FILL BYTE FOR FORMAT
EFD0 19                         DB      25              ; HEAD SETTLE TIME (MILLISECONDS)
EFD1 04                         DB      4               ; MOTOR START TIME (1/8 SECONDS)

                        ;--- INT 17 ---------------------------------------------------------
                        ; PRINTER_IO                                                         :
                        ;       THIS ROUTINE PROVIDES COMMUNICATION WITH THE PRINTER         :
                        ; INPUT                                                              :
                        ;       (AH)=0  PRINT THE CHARACTER IN (AL)                          :
                        ;               ON RETURN, AH=1 IF CHARACTER COULD NOT BE PRINTED    :
                        ;               (TIME OUT). OTHER BITS SET AS ON NORMAL STATUS CALL  :
                        ;       (AH)=1  INITIALIZE THE PRINTER PORT                          :
                        ;               RETURNS WITH (AH) SET WITH PRINTER STATUS            :
                        ;       (AH)=2  READ THE PRINTER STATUS INTO (AH)                    :
                        ;               7       6       5       4       3       2-1  0       :
                        ;               |       |       |       |       |       |    |_TIME OUT :
                        ;               |       |       |       |       |       |_ UNUSED    :
                        ;               |       |       |       |       |_ 1 = I/O ERROR     :
                        ;               |       |       |       |_ 1 = SELECTED              :
                        ;               |       |       |_ 1 = OUT OF PAPER                  :
                        ;               |       |_ 1 = ACKNOWLEDGE                           :
                        ;               |_ 1 = NOT BUSY                                      :
                        ;                                                                    :
                        ;       (DX) = PRINTER TO BE USED (0,1,2) CORRESPONDING TO ACTUAL    :
                        ;               VALUES IN PRINTER_BASE AREA                          :
                        ;                                                                    :
                        ; DATA AREA PRINTER_BASE CONTAINS THE BASE ADDRESS OF THE PRINTER   :
                        ; CARD(S) AVAILABLE (LOCATED AT BEGINNING OF DATA SEGMENT,           :
                        ; 408H ABSOLUTE, 3 WORDS)                                            :
                        ;                                                                    :
                        ; DATA AREA PRINT_TIM_OUT (BYTE) MAY BE CHANGED TO CAUSE DIFFERENT  :
                        ; TIME-OUT WAITS. DEFAULT=20                                         :
                        ;                                                                    :
                        ; REGISTERS     AH IS MODIFIED                                       :
                        ;               ALL OTHERS UNCHANGED                                 :
                        ;--------------------------------------------------------------------
                                ASSUME  CS:CODE,DS:DATA
EFD2                            ORG     0EFD2H
EFD2                    PRINTER_IO      PROC    FAR
EFD2 FB                         STI                             ; INTERRUPTS BACK ON
EFD3 1E                         PUSH    DS                      ; SAVE SEGMENT
EFD4 52                         PUSH    DX
EFD5 56                         PUSH    SI
EFD6 51                         PUSH    CX
EFD7 53                         PUSH    BX
EFD8 E8630F                     CALL    DDS
EFDB 8BF2                       MOV     SI,DX                   ; GET PRINTER PARM
EFDD 8A5C78                     MOV     BL,PRINT TIM OUT[SI]    ; LOAD TIME-OUT PARM
EFE0 D1E6                       SHL     SI,1                    ; WORD OFFSET INTO TABLE
EFE2 8B5408                     MOV     DX,PRINTER_BASE[SI]     ; GET BASE ADDRESS FOR PRINTER CARD
EFE5 0BD2                       OR      DX,DX                   ; TEST DX FOR ZERO,
                                                                ;  INDICATING NO PRINTER
EFE7 740C                       JZ      B1                      ; RETURN
EFE9 0AE4                       OR      AH,AH                   ; TEST FOR (AH)=0
EFEB 740E                       JZ      B2                      ; PRINT_AL
EFED FECC                       DEC     AH                      ; TEST FOR (AH)=1
EFEF 743F                       JZ      B8                      ; INIT_PRT
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LOC OBJ                 SOURCE

EFF1 FECC                       DEC     AH                      ; TEST FOR (AH)=2
EFF3 7428                       JZ      B5                      ; PRINTER STATUS
EFF5                    B1:                                     ; RETURN
EFF5 5B                         POP     BX
EFF6 59                         POP     CX
EFF7 5E                         POP     SI                      ; RECOVER REGISTERS
EFF8 5A                         POP     DX                      ; RECOVER REGISTERS
EFF9 1F                         POP     DS
EFFA CF                         IRET

                        ;------ PRINT THE CHARACTER IN (AL)

EFFB                    B2:
EFFB 50                         PUSH    AX                      ; SAVE VALUE TO PRINT
EFFC EE                         OUT     DX,AL                   ; OUTPUT CHAR TO PORT
EFFD 42                         INC     DX                      ; POINT TO STATUS PORT
EFFE                    B3:
EFFE 2BC9                       SUB     CX,CX                   ; WAIT_BUSY
F000                    B3_1:
F000 EC                         IN      AL,DX                   ; GET STATUS
F001 8AE0                       MOV     AH,AL                   ; STATUS TO AH ALSO
F003 A880                       TEST    AL,80H                  ; IS THE PRINTER CURRENTLY BUSY
F005 750E                       JNZ     B4                      ; OUT_STROBE
F007 E2F7                       LOOP    B3_1                    ; TRY AGAIN
F009 FECB                       DEC     BL                      ; DROP LOOP COUNT
F00B 75F1                       JNZ     B3                      ; GO TILL TIMEOUT ENDS
F00D 80CC01                     OR      AH,1                    ; SET ERROR FLAG
F010 80E4F9                     AND     AH,0F9H                 ; TURN OFF THE OTHER BITS
F013 EB13                       JMP     SHORT B7                ; RETURN WITH ERROR FLAG SET
F015                    B4:                                     ; OUT_STROBE
F015 B00D                       MOV     AL,0DH                  ; SET THE STROBE HIGH
F017 42                         INC     DX                      ; STROBE IS BIT 0 OF PORT C OF 8255
F018 EE                         OUT     DX,AL
F019 B00C                       MOV     AL,0CH                  ; SET THE STROBE LOW
F01B EE                         OUT     DX,AL
F01C 58                         POP     AX                      ; RECOVER THE OUTPUT CHAR

                        ;------ PRINTER STATUS

F01D                    B5:
F01D 50                         PUSH    AX                      ; SAVE AL REG
F01E                    B6:
F01E 8B5408                     MOV     DX,PRINTER_BASE[SI]
F021 42                         INC     DX
F022 EC                         IN      AL,DX                   ; GET PRINTER STATUS
F023 8AE0                       MOV     AH,AL
F025 80E4F8                     AND     AH,0F8H                 ; TURN OFF UNUSED BITS
F028                    B7:                                     ; STATUS_SET
F028 5A                         POP     DX                      ; RECOVER AL REG
F029 8AC2                       MOV     AL,DL                   ; GET CHARACTER INTO AL
F02B 80F448                     XOR     AH,48H                  ; FLIP A COUPLE OF BITS
F02E EBC5                       JMP     B1                      ; RETURN FROM ROUTINE

                        ;------ INITIALIZE THE PRINTER PORT

F030                    B8:
F030 50                         PUSH    AX                      ; SAVE AL
F031 42                         INC     DX                      ; POINT TO OUTPUT PORT
F032 42                         INC     DX
F033 B008                       MOV     AL,8                    ; SET INIT LINE LOW
F035 EE                         OUT     DX,AL
F036 B8E803                     MOV     AX,1000
F039                    B9:                                     ; INIT_LOOP
F039 48                         DEC     AX                      ; LOOP FOR RESET TO TAKE
F03A 75FD                       JNZ     B9                      ; INIT_LOOP
F03C B00C                       MOV     AL,0CH                  ; NO INTERRUPTS, NON AUTO LF,
                                                                ;  INIT HIGH
F03E EE                         OUT     DX,AL
F03F EBDD                       JMP     B6                      ; PRT_STATUS_1
                        PRINTER_IO      ENDP

F041 62E1               C2      DW      C24                     ; RETURN ADDRESS FOR DUMMY STACK

                        ;--- INT 10 ------------------------------------------------------------
                        ; VIDEO_IO                                                              :
                        ;       THESE ROUTINES PROVIDE THE CRT INTERFACE                        :
                        ;       THE FOLLOWING FUNCTIONS ARE PROVIDED:                           :
```

LOC OBJ LINE SOURCE

```
;       (AH)=0  SET MODE (AL) CONTAINS MODE VALUE                      :
;               (AL)=0 40X25 BW (POWER ON DEFAULT)                     :
;               (AL)=1 40X25 COLOR                                     :
;               (AL)=2  80X25 BW                                       :
;               (AL)=3  80X25 COLOR                                    :
;               GRAPHICS MODES                                         :
;               (AL)=4  320X200 COLOR                                  :
;               (AL)=5  320X200 BW                                     :
;               (AL)=6  640X200 BW                                     :
;               CRT MODE=7 80X25 B&W CARD (USED INTERNAL TO VIDEO ONLY) :
;               *** NOTE BW MODES OPERATE SAME AS COLOR MODES, BUT     :
;                        COLOR BURST IS NOT ENABLED                    :
;       (AH)=1  SET CURSOR TYPE                                        :
;               (CH) =  BITS 4-0 = START LINE FOR CURSOR               :
;                       ** HARDWARE WILL ALWAYS CAUSE BLIN             :
;                       ** SETTING BIT 5 OR 6 WILL CAUSE ERRATIC       :
;                          BLINKING OR NO CURSOR AT ALL                :
;               (CL) =  BITS 4-0 = END LINE FOR CURSOR                 :
;       (AH)=2  SET CURSOR POSITION                                    :
;               (DH,DL) = ROW,COLUMN  (0,0) IS UPPER LEFT              :
;               (BH) = PAGE NUMBER (MUST BE 0 FOR GRAPHICS MODES)      :
;       (AH)=3  READ CURSOR POSITION                                   :
;               (BH) = PAGE NUMBER (MUST BE 0 FOR GRAPHICS MODES)      :
;               ON EXIT (DH,DL) = ROW,COLUMN OF CURRENT CURSOR         :
;                       (CH,CL) = CURSOR MODE CURRENTLY SET            :
;       (AH)=4  READ LIGHT PEN POSITION                                :
;               ON EXIT:                                               :
;               (AH) = 0 -- LIGHT PEN SWITCH NOT DOWN/NOT TRIGGERED    :
;               (AH) = 1 -- VALID LIGHT PEN VALUE IN REGISTERS         :
;                       (DH,DL) = ROW,COLUMN OF CHARACTER LP POSN      :
;                       (CH) = RASTER LINE (0-199)                     :
;                       (BX) = PIXEL COLUMN (0-319,639)                :
;       (AH)=5  SELECT ACTIVE DISPLAY PAGE (VALID ONLY FOR ALPHA MODES) :
;               (AL)=NEW PAGE VAL (0-7 FOR MODES 0&1, 0-3 FOR MODES 2&3):
;       (AH)=6  SCROLL ACTIVE PAGE UP                                  :
;               (AL) = NUMBER OF LINES, INPUT LINES BLANKED AT BOTTOM  :
;                      OF WINDOW                                       :
;                       AL = 0 MEANS BLANK ENTIRE WINDOW               :
;               (CH,CL) = ROW,COLUMN OF UPPER LEFT CORNER OF SCROLL    :
;               (DH,DL) = ROW,COLUMN OF LOWER RIGHT CORNER OF SCROLL   :
;               (BH) = ATTRIBUTE TO BE USED ON BLANK LINE              :
;       (AH)=7  SCROLL ACTIVE PAGE DOWN                                :
;               (AL) = NUMBER OF LINES, INPUT LINES BLANKED AT TOP     :
;                      OF WINDOW                                       :
;                       AL = 0 MEANS BLANK ENTIRE WINDOW               :
;               (CH,CL) = ROW,COLUMN OF UPPER LEFT CORNER OF SCROLL    :
;               (DH,DL) = ROW,COLUMN OF LOWER RIGHT CORNER OF SCROLL   :
;               (BH) = ATTRIBUTE TO BE USED ON BLANK LINE              :
;                                                                      :
;       CHARACTER HANDLING ROUTINES                                    :
;                                                                      :
;       (AH) = 8 READ ATTRIBUTE/CHARACTER AT CURRENT CURSOR POSITION   :
;               (BH) = DISPLAY PAGE (VALID FOR ALPHA MODES ONLY)       :
;               ON EXIT:                                               :
;               (AL) = CHAR READ                                       :
;               (AH) = ATTRIBUTE OF CHARACTER READ (ALPHA MODES ONLY)  :
;       (AH) = 9 WRITE ATTRIBUTE/CHARACTER AT CURRENT CURSOR POSITION  :
;               (BH) = DISPLAY PAGE (VALID FOR ALPHA MODES ONLY)       :
;               (CX) = COUNT OF CHARACTERS TO WRITE                    :
;               (AL) = CHAR TO WRITE                                   :
;               (BL) = ATTRIBUTE OF CHARACTER (ALPHA)/COLOR OF CHAR    :
;                      (GRAPHICS)                                      :
;                       SEE NOTE ON WRITE DOT FOR BIT 7 OF BL = 1.     :
;       (AH) = 10 WRITE CHARACTER ONLY AT CURRENT CURSOR POSITION      :
;               (BH) = DISPLAY PAGE (VALID FOR ALPHA MODES ONLY)       :
;               (CX) = COUNT OF CHARACTERS TO WRITE                    :
;               (AL) = CHAR TO WRITE                                   :
;       FOR READ/WRITE CHARACTER INTERFACE WHILE IN GRAPHICS MODE, THE :
;               CHARACTERS ARE FORMED FROM A CHARACTER GENERATOR IMAGE :
;               MAINTAINED IN THE SYSTEM ROM.  ONLY THE 1ST 128 CHARS  :
;               ARE CONTAINED THERE.  TO READ/WRITE THE SECOND 128     :
;               CHARS, THE USER MUST INITIALIZE THE POINTER AT         :
;               INTERRUPT 1FH (LOCATION 0007CH) TO POINT TO THE 1K BYTE :
;               TABLE CONTAINING THE CODE POINTS FOR THE SECOND        :
;               128 CHARS (128-255).                                   :
;       FOR WRITE CHARACTER INTERFACE IN GRAPHICS MODE, THE REPLICATION :
;               FACTOR CONTAINED IN (CX) ON ENTRY WILL PRODUCE VALID   :
```

```
LOC OBJ          SOURCE

                 ;               RESULTS ONLY FOR CHARACTERS CONTAINED ON THE SAME ROW.  :
                 ;               CONTINUATION TO SUCCEEDING LINES WILL NOT PRODUCE       :
                 ;               CORRECTLY.                                              :
                 ;                                                                       :
                 ;       GRAPHICS INTERFACE                                              :
                 ;       (AH) = 11 SET COLOR PALETTE                                     :
                 ;               (BH) = PALETTE COLOR ID BEING SET (0-127)               :
                 ;               (BL) = COLOR VALUE TO BE USED WITH THAT COLOR ID        :
                 ;                  NOTE: FOR THE CURRENT COLOR CARD, THIS ENTRY POINT   :
                 ;                        HAS MEANING ONLY FOR 320X200 GRAPHICS.         :
                 ;                       COLOR ID = 0 SELECTS THE BACKGROUND COLOR (0-15):
                 ;                       COLOR ID = 1 SELECTS THE PALETTE TO BE USED:    :
                 ;                               0 = GREEN(1)/RED(2)/YELLOW(3)           :
                 ;                               1 = CYAN(1)/MAGENTA(2)/WHITE(3)         :
                 ;                       IN 40X25 OR 80X25 ALPHA MODES, THE VALUE SET    :
                 ;                               FOR PALETTE COLOR 0 INDICATES THE       :
                 ;                               BORDER COLOR TO BE USED (VALUES 0-31,   :
                 ;                               WHERE 16-31 SELECT THE HIGH INTENSITY   :
                 ;                               BACKGROUND SET.                         :
                 ;       (AH) = 12 WRITE DOT                                             :
                 ;               (DX) = ROW NUMBER                                       :
                 ;               (CX) = COLUMN NUMBER                                    :
                 ;               (AL) = COLOR VALUE                                      :
                 ;                       IF BIT 7 OF AL = 1, THEN THE COLOR VALUE IS     :
                 ;                       EXCLUSIVE OR'D WITH THE CURRENT CONTENTS OF     :
                 ;                       THE DOT                                         :
                 ;       (AH) = 13 READ DOT                                              :
                 ;               (DX) = ROW NUMBER                                       :
                 ;               (CX) = COLUMN NUMBER                                    :
                 ;               (AL) RETURNS THE DOT READ                               :
                 ;                                                                       :
                 ; ASCII TELETYPE ROUTINE FOR OUTPUT                                     :
                 ;                                                                       :
                 ;       (AH) = 14 WRITE TELETYPE TO ACTIVE PAGE                         :
                 ;               (AL) = CHAR TO WRITE                                    :
                 ;               (BL) = FOREGROUND COLOR IN GRAPHICS MODE                :
                 ;               NOTE -- SCREEN WIDTH IS CONTROLLED BY PREVIOUS MODE SET :
                 ;                                                                       :
                 ;       (AH) = 15 CURRENT VIDEO STATE                                   :
                 ;               RETURNS THE CURRENT VIDEO STATE                         :
                 ;               (AL) = MODE CURRENTLY SET ( SEE AH=0 FOR EXPLANATION)   :
                 ;               (AH) = NUMBER OF CHARACTER COLUMNS ON SCREEN            :
                 ;               (BH) = CURRENT ACTIVE DISPLAY PAGE                      :
                 ;                                                                       :
                 ;       CS,SS,DS,ES,BX,CX,DX PRESERVED DURING CALL                      :
                 ;       ALL OTHERS DESTROYED                                            :
                 ;------------------------------------------------------------------------
                         ASSUME  CS:CODE,DS:DATA,ES:VIDEO_RAM
F045                     ORG     0F045H
F045             M1      LABEL   WORD                    ; TABLE OF ROUTINES WITHIN VIDEO I/O
F045 FCF0                DW      OFFSET  SET_MODE
F047 CDF1                DW      OFFSET  SET_CTYPE
F049 EEF1                DW      OFFSET  SET_CPOS
F04B 39F2                DW      OFFSET  READ_CURSOR
F04D 9CF7                DW      OFFSET  READ_LPEN
F04F 17F2                DW      OFFSET  ACT_DISP_PAGE
F051 96F2                DW      OFFSET  SCROLL_UP
F053 38F3                DW      OFFSET  SCROLL_DOWN
F055 74F3                DW      OFFSET  READ_AC_CURRENT
F057 B9F3                DW      OFFSET  WRITE_AC_CURRENT
F059 ECF3                DW      OFFSET  WRITE_C_CURRENT
F05B 4EF2                DW      OFFSET  SET_COLOR
F05D 2FF4                DW      OFFSET  WRITE_DOT
F05F 1EF4                DW      OFFSET  READ_DOT
F061 18F7                DW      OFFSET  WRITE_TTY
F063 74F2                DW      OFFSET  VIDEO_STATE
 0020            M1L     EQU     $-M1

F065                     ORG     0F065H
F065             VIDEO_IO        PROC    NEAR
F065 FB                  STI                             ; INTERRUPTS BACK ON
F066 FC                  CLD                             ; SET DIRECTION FORWARD
F067 06                  PUSH    ES
F068 1E                  PUSH    DS                      ; SAVE SEGMENT REGISTERS
F069 52                  PUSH    DX
F06A 51                  PUSH    CX
F06B 53                  PUSH    BX
```

Section 5

```
LOC OBJ                  LINE    SOURCE

F06C 56                                  PUSH    SI
F06D 57                                  PUSH    DI
F06E 50                                  PUSH    AX                      ; SAVE AX VALUE
F06F 8AC4                                MOV     AL,AH                   ; GET INTO LOW BYTE
F071 32E4                                XOR     AH,AH                   ; ZERO TO HIGH BYTE
F073 D1E0                                SAL     AX,1                    ; *2 FOR TABLE LOOKUP
F075 8BF0                                MOV     SI,AX                   ; PUT INTO SI FOR BRANCH
F077 3D2000                              CMP     AX,M1L                  ; TEST FOR WITHIN RANGE
F07A 7204                                JB      M2                      ; BRANCH AROUND BRANCH
F07C 58                                  POP     AX                      ; THROW AWAY THE PARAMETER
F07D E94501                              JMP     VIDEO_RETURN            ; DO NOTHING IF NOT IN RANGE
F080                             M2:
F080 E8BB0E                              CALL    DDS
F083 B800B8                              MOV     AX,0B800H               ; SEGMENT FOR COLOR CARD
F086 8B3E1000                            MOV     DI,EQUIP_FLAG           ; GET EQUIPMENT SETTING
F08A 81E73000                            AND     DI,30H                  ; ISOLATE CRT SWITCHES
F08E 83FF30                              CMP     DI,30H                  ; IS SETTING FOR BW CARD?
F091 7502                                JNE     M3
F093 B4B0                                MOV     AH,0B0H                 ; SEGMENT FOR BW CARD
F095                             M3:
F095 8EC0                                MOV     ES,AX                   ; SET UP TO POINT AT VIDEO RAM AREAS
F097 58                                  POP     AX                      ; RECOVER VALUE
F098 8A264900                            MOV     AH,CRT_MODE             ; GET CURRENT MODE INTO AH
F09C 2EFFA445F0                          JMP     WORD PTR CS:[SI+OFFSET M1]
                                 VIDEO_IO        ENDP
                                 ;------------------------------------------------------
                                 ; SET_MODE                                            :
                                 ;       THIS ROUTINE INITIALIZES THE ATTACHMENT TO    :
                                 ;       THE SELECTED MODE.  THE SCREEN IS BLANKED.    :
                                 ; INPUT                                               :
                                 ;       (AL) = MODE SELECTED (RANGE 0-9)              :
                                 ; OUTPUT                                              :
                                 ;       NONE                                          :
                                 ;------------------------------------------------------

                                 ;----- TABLES FOR USE IN SETTING OF MODE

F0A4                                     ORG     0F0A4H
F0A4                             VIDEO_PARMS     LABEL   BYTE
                                 ;----- INIT_TABLE
F0A4 38                                  DB      38H,28H,2DH,0AH,1FH,6,19H       ; SET UP FOR 40X25
F0A5 28
F0A6 2D
F0A7 0A
F0A8 1F
F0A9 06
F0AA 19
F0AB 1C                                  DB      1CH,2,7,6,7
F0AC 02
F0AD 07
F0AE 06
F0AF 07
F0B0 00                                  DB      0,0,0,0
F0B1 00
F0B2 00
F0B3 00
  0010                           M4      EQU     $-VIDEO_PARMS

F0B4 71                                  DB      71H,50H,5AH,0AH,1FH,6,19H       ; SET UP FOR 80X25
F0B5 50
F0B6 5A
F0B7 0A
F0B8 1F
F0B9 06
F0BA 19
F0BB 1C                                  DB      1CH,2,7,6,7
F0BC 02
F0BD 07
F0BE 06
F0BF 07
F0C0 00                                  DB      0,0,0,0
F0C1 00
F0C2 00
F0C3 00

F0C4 38                                  DB      38H,28H,2DH,0AH,7FH,6,64H       ; SET UP FOR GRAPHICS
F0C5 28
```

```
LOC OBJ                 LINE    SOURCE

F0C6 2D
F0C7 0A
F0C8 7F
F0C9 06
F0CA 64
F0CB 70                                 DB      70H,2,1,6,7
F0CC 02
F0CD 01
F0CE 06
F0CF 07
F0D0 00                                 DB      0,0,0,0
F0D1 00
F0D2 00
F0D3 00

F0D4 61                                 DB      61H,50H,52H,0FH,19H,6,19H       ; SET UP FOR 80X25 B&W CARD
F0D5 50
F0D6 52
F0D7 0F
F0D8 19
F0D9 06
F0DA 19
F0DB 19                                 DB      19H,2,0DH,0BH,0CH
F0DC 02
F0DD 0D
F0DE 0B
F0DF 0C
F0E0 00                                 DB      0,0,0,0
F0E1 00
F0E2 00
F0E3 00

F0E4                            M5      LABEL   WORD                    ; TABLE OF REGEN LENGTHS
F0E4 0008                               DW      2048                    ; 40X25
F0E6 0010                               DW      4096                    ; 80X25
F0E8 0040                               DW      16384                   ; GRAPHICS
F0EA 0040                               DW      16384

                                ;----- COLUMNS

F0EC                            M6      LABEL   BYTE
F0EC 28                                 DB      40,40,80,80,40,40,80,80
F0ED 28
F0EE 50
F0EF 50
F0F0 28
F0F1 28
F0F2 50
F0F3 50

                                ;----- C_REG_TAB

F0F4                            M7      LABEL   BYTE                    ; TABLE OF MODE SETS
F0F4 2C                                 DB      2CH,28H,2DH,29H,2AH,2EH,1EH,29H
F0F5 28
F0F6 2D
F0F7 29
F0F8 2A
F0F9 2E
F0FA 1E
F0FB 29

F0FC                            SET_MODE        PROC    NEAR
F0FC BAD403                             MOV     DX,03D4H                ; ADDRESS OF COLOR CARD
F0FF B300                               MOV     BL,0                    ; MODE SET FOR COLOR CARD
F101 83FF30                             CMP     DI,30H                  ; IS BW CARD INSTALLED
F104 7506                               JNE     M8                      ; OK WITH COLOR
F106 B007                               MOV     AL,7                    ; INDICATE BW CARD MODE
F108 B2B4                               MOV     DL,0B4H                 ; ADDRESS OF BW CARD (3B4)
F10A FEC3                               INC     BL                      ; MODE SET FOR BW CARD
F10C                            M8:
F10C 8AE0                               MOV     AH,AL                   ; SAVE MODE IN AH
F10E A24900                             MOV     CRT_MODE,AL             ; SAVE IN GLOBAL VARIABLE
F111 89166300                           MOV     ADDR_6845,DX            ; SAVE ADDRESS OF BASE
F115 1E                                 PUSH    DS                      ; SAVE POINTER TO DATA SEGMENT
F116 50                                 PUSH    AX                      ; SAVE MODE
F117 52                                 PUSH    DX                      ; SAVE OUTPUT PORT VALUE
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LOC OBJ                 SOURCE

F118 83C204                     ADD     DX,4                    ; POINT TO CONTROL REGISTER
F11B 8AC3                       MOV     AL,BL                   ; GET MODE SET FOR CARD
F11D EE                         OUT     DX,AL                   ; RESET VIDEO
F11E 5A                         POP     DX                      ; BACK TO BASE REGISTER
F11F 2BC0                       SUB     AX,AX                   ; SET UP FOR ABS0 SEGMENT
F121 8ED8                       MOV     DS,AX                   ; ESTABLISH VECTOR TABLE ADDRESSING
                                ASSUME  DS:ABS0
F123 C51E7400                   LDS     BX,PARM_PTR             ; GET POINTER TO VIDEO PARMS
F127 58                         POP     AX                      ; RECOVER PARMS
                                ASSUME  DS:CODE
F128 B91000                     MOV     CX,M4                   ; LENGTH OF EACH ROW OF TABLE
F12B 80FC02                     CMP     AH,2                    ; DETERMINE WHICH ONE TO USE
F12E 7210                       JC      M9                      ; MODE IS 0 OR 1
F130 03D9                       ADD     BX,CX                   ; MOVE TO NEXT ROW OF INIT TABLE
F132 80FC04                     CMP     AH,4
F135 7209                       JC      M9                      ; MODE IS 2 OR 3
F137 03D9                       ADD     BX,CX                   ; MOVE TO GRAPHICS ROW OF INIT_TABLE
F139 80FC07                     CMP     AH,7
F13C 7202                       JC      M9                      ; MODE IS 4,5, OR 6
F13E 03D9                       ADD     BX,CX                   ; MOVE TO BW CARD ROW OF INIT_TABLE

                        ;----- BX POINTS TO CORRECT ROW OF INITIALIZATION TABLE

F140                    M9:                                     ; OUT_INIT
F140 50                         PUSH    AX                      ; SAVE MODE IN AH
F141 32E4                       XOR     AH,AH                   ; AH WILL SERVE AS REGISTER
                                                                ;  NUMBER DURING LOOP

                        ;----- LOOP THROUGH TABLE, OUTPUTTTING REG ADDRESS, THEN VALUE FROM TABLE

F143                    M10:                                    ; INIT LOOP
F143 8AC4                       MOV     AL,AH                   ; GET 6845 REGISTER NUMBER
F145 EE                         OUT     DX,AL
F146 42                         INC     DX                      ; POINT TO DATA PORT
F147 FEC4                       INC     AH                      ; NEXT REGISTER VALUE
F149 8A07                       MOV     AL,[BX]                 ; GET TABLE VALUE
F14B EE                         OUT     DX,AL                   ; OUT TO CHIP
F14C 43                         INC     BX                      ; NEXT IN TABLE
F14D 4A                         DEC     DX                      ; BACK TO POINTER REGISTER
F14E E2F3                       LOOP    M10                     ; DO THE WHOLE TABLE
F150 58                         POP     AX                      ; GET MODE BACK
F151 1F                         POP     DS                      ; RECOVER SEGMENT VALUE
                                ASSUME  DS:DATA

                        ;----- FILL REGEN AREA WITH BLANK

F152 33FF                       XOR     DI,DI                   ; SET UP POINTER FOR REGEN
F154 893E4E00                   MOV     CRT_START,DI            ; START ADDRESS SAVED IN GLOBAL
F158 C606620000                 MOV     ACTIVE_PAGE,0           ; SET PAGE VALUE
F15D B90020                     MOV     CX,8192                 ; NUMBER OF WORDS IN COLOR CARD
F160 80FC04                     CMP     AH,4                    ; TEST FOR GRAPHICS
F163 720B                       JC      M12                     ; NO_GRAPHICS_INIT
F165 80FC07                     CMP     AH,7                    ; TEST FOR BW CARD
F168 7404                       JE      M11                     ; BW_CARD_INIT
F16A 33C0                       XOR     AX,AX                   ; FILL FOR GRAPHICS MODE
F16C EB05                       JMP     SHORT M13               ; CLEAR_BUFFER
F16E                    M11:                                    ; BW_CARD_INIT
F16E B508                       MOV     CH,08H                  ; BUFFER SIZE ON BW CARD
F170                    M12:                                    ; NO_GRAPHICS_INIT
F170 B82007                     MOV     AX,' '+7*256            ; FILL CHAR FOR ALPHA
F173                    M13:                                    ; CLEAR_BUFFER
F173 F3                         REP     STOSW                   ; FILL THE REGEN BUFFER WITH BLANKS
F174 AB

                        ;----- ENABLE VIDEO AND CORRECT PORT SETTING

F175 C70660000706               MOV     CURSOR_MODE,607H        ; SET CURRENT CURSOR MODE
F17B A04900                     MOV     AL,CRT_MODE             ; GET THE MODE
F17E 32E4                       XOR     AH,AH                   ;  INTO AX REGISTER
F180 8BF0                       MOV     SI,AX                   ; TABLE POINTER, INDEXED BY MODE
F182 8B166300                   MOV     DX,ADDR_6845            ; PREPARE TO OUTPUT TO
                                                                ;  VIDEO ENABLE PORT
F186 83C204                     ADD     DX,4
F189 2E8A84F4F0                 MOV     AL,CS:[SI+OFFSET M7]
F18E EE                         OUT     DX,AL                   ; SET VIDEO ENABLE PORT
F18F A26500                     MOV     CRT_MODE_SET,AL         ; SAVE THAT VALUE
```

```
LOC OBJ                 SOURCE

                        ;----- DETERMINE NUMBER OF COLUMNS, BOTH FOR ENTIRE DISPLAY
                        ;----- AND THE NUMBER TO BE USED FOR TTY INTERFACE

F192 2E8A84ECF0                 MOV     AL,CS:[SI + OFFSET M6]
F197 32E4                       XOR     AH,AH
F199 A34A00                     MOV     CRT_COLS,AX             ; NUMBER OF COLUMNS IN THIS SCREEN

                        ;----- SET CURSOR POSITIONS

F19C 81E60E00                   AND     SI,0EH                  ; WORD OFFSET INTO CLEAR LENGTH TABLE
F1A0 2E8B8CE4F0                 MOV     CX,CS:[SI + OFFSET M5]  ; LENGTH TO CLEAR
F1A5 890E4C00                   MOV     CRT_LEN,CX              ; SAVE LENGTH OF CRT -- NOT USED FOR BW
F1A9 B90800                     MOV     CX,8                    ; CLEAR ALL CURSOR POSITIONS
F1AC BF5000                     MOV     DI,OFFSET CURSOR_POSN
F1AF 1E                         PUSH    DS                      ; ESTABLISH SEGMENT
F1B0 07                         POP     ES                      ;   ADDRESSING
F1B1 33C0                       XOR     AX,AX
F1B3 F3                         REP     STOSW                   ; FILL WITH ZEROES
F1B4 AB

                        ;----- SET UP OVERSCAN REGISTER

F1B5 42                         INC     DX                      ; SET OVERSCAN PORT TO A DEFAULT
F1B6 B030                       MOV     AL,30H                  ; VALUE OF 30H FOR ALL MODES
                                                                ;  EXCEPT 640X200
F1B8 803E490006                 CMP     CRT_MODE,6              ; SEE IF THE MODE IS 640X200 BW
F1BD 7502                       JNZ     M14                     ; IF IT ISNT 640X200, THEN GOTO REGULAR
F1BF B03F                       MOV     AL,3FH                  ; IF IT IS 640X200, THEN PUT IN 3FH
F1C1                    M14:
F1C1 EE                         OUT     DX,AL                   ; OUTPUT THE CORRECT VALUE TO 3D9 PORT
F1C2 A26600                     MOV     CRT_PALETTE,AL          ; SAVE THE VALUE FOR FUTURE USE

                        ;----- NORMAL RETURN FROM ALL VIDEO RETURNS

F1C5                    VIDEO_RETURN:
F1C5 5F                         POP     DI
F1C6 5E                         POP     SI
F1C7 5B                         POP     BX
F1C8                    M15:                                    ; VIDEO_RETURN_C
F1C8 59                         POP     CX
F1C9 5A                         POP     DX
F1CA 1F                         POP     DS
F1CB 07                         POP     ES                      ; RECOVER SEGMENTS
F1CC CF                         IRET                            ; ALL DONE
                        SET_MODE        ENDP
                        ;--------------------------------------------------------------
                        ; SET_CTYPE                                                    :
                        ;       THIS ROUTINE SETS THE CURSOR VALUE                     :
                        ; INPUT                                                        :
                        ;       (CX) HAS CURSOR VALUE CH-START LINE, CL-STOP LINE      :
                        ; OUTPUT                                                       :
                        ;       NONE                                                   :
                        ;--------------------------------------------------------------
F1CD                    SET_CTYPE       PROC    NEAR
F1CD B40A                       MOV     AH,10                   ; 6845 REGISTER FOR CURSOR SET
F1CF 890E6000                   MOV     CURSOR_MODE,CX          ; SAVE IN DATA AREA
F1D3 E80200                     CALL    M16                     ; OUTPUT CX REG
F1D6 EBED                       JMP     VIDEO_RETURN

                        ;----- THIS ROUTINE OUTPUTS THE CX REGISTER TO THE 6845 REGS NAMED IN AH

F1D8                    M16:
F1D8 8B166300                   MOV     DX,ADDR_6845            ; ADDRESS REGISTER
F1DC 8AC4                       MOV     AL,AH                   ; GET VALUE
F1DE EE                         OUT     DX,AL                   ; REGISTER SET
F1DF 42                         INC     DX                      ; DATA REGISTER
F1E0 8AC5                       MOV     AL,CH                   ; DATA
F1E2 EE                         OUT     DX,AL
F1E3 4A                         DEC     DX
F1E4 8AC4                       MOV     AL,AH
F1E6 FEC0                       INC     AL                      ; POINT TO OTHER DATA REGISTER
F1E8 EE                         OUT     DX,AL                   ; SET FOR SECOND REGISTER
F1E9 42                         INC     DX
F1EA 8AC1                       MOV     AL,CL                   ; SECOND DATA VALUE
F1EC EE                         OUT     DX,AL
F1ED C3                         RET                             ; ALL DONE
                        SET_CTYPE       ENDP
```

Section 5

```
LOC OBJ                  LINE    SOURCE

                                 ;-----------------------------------------------
                                 ; SET_CPOS                                     :
                                 ;       THIS ROUTINE SETS THE CURRENT CURSOR   :
                                 ;       POSITION TO THE NEW X-Y VALUES PASSED  :
                                 ; INPUT                                        :
                                 ;       DX - ROW,COLUMN OF NEW CURSOR          :
                                 ;       BH - DISPLAY PAGE OF CURSOR            :
                                 ; OUTPUT                                       :
                                 ;       CURSOR IS SET AT 6845 IF DISPLAY PAGE  :
                                 ;       IS CURRENT DISPLAY                     :
                                 ;-----------------------------------------------
F1EE                             SET_CPOS        PROC    NEAR
F1EE 8ACF                                MOV     CL,BH
F1F0 32ED                                XOR     CH,CH                   ; ESTABLISH LOOP COUNT
F1F2 D1E1                                SAL     CX,1                    ; WORD OFFSET
F1F4 8BF1                                MOV     SI,CX                   ; USE INDEX REGISTER
F1F6 895450                              MOV     [SI+OFFSET CURSOR_POSN],DX      ; SAVE THE POINTER
F1F9 383E6200                            CMP     ACTIVE_PAGE,BH
F1FD 7505                                JNZ     M17                     ; SET_CPOS_RETURN
F1FF 8BC2                                MOV     AX,DX                   ; GET ROW/COLUMN TO AX
F201 E80200                              CALL    M18                     ; CURSOR_SET
F204                             M17:                                    ; SET_CPOS_RETURN
F204 EBBF                                JMP     VIDEO_RETURN
                                 SET_CPOS        ENDP

                                 ;----- SET CURSOR POSITION, AX HAS ROW/COLUMN FOR CURSOR

F206                             M18     PROC    NEAR
F206 E87C00                              CALL    POSITION                ; DETERMINE LOCATION IN REGEN BUFFER
F209 8BC8                                MOV     CX,AX
F20B 030E4E00                            ADD     CX,CRT_START            ; ADD IN THE START ADDR FOR THIS PAGE
F20F D1F9                                SAR     CX,1                    ; DIVIDE BY 2 FOR CHAR ONLY COUNT
F211 B40E                                MOV     AH,14                   ; REGISTER NUMBER FOR CURSOR
F213 E8C2FF                              CALL    M16                     ; OUTPUT THE VALUE TO THE 6845
F216 C3                                  RET
                                 M18     ENDP
                                 ;--------------------------------------------------------------
                                 ; ACT_DISP_PAGE                                               :
                                 ;       THIS ROUTINE SETS THE ACTIVE DISPLAY PAGE, ALLOWING THE :
                                 ;       FULL USE OF THE RAM SET ASIDE FOR THE VIDEO ATTACHMENT  :
                                 ; INPUT                                                       :
                                 ;       AL HAS THE NEW ACTIVE DISPLAY PAGE                    :
                                 ; OUTPUT                                                      :
                                 ;       THE 6845 IS RESET TO DISPLAY THAT PAGE                :
                                 ;--------------------------------------------------------------
F217                             ACT_DISP_PAGE   PROC    NEAR
F217 A26200                              MOV     ACTIVE_PAGE,AL          ; SAVE ACTIVE PAGE VALUE
F21A 8B0E4C00                            MOV     CX,CRT_LEN              ; GET SAVED LENGTH OF REGEN BUFFER
F21E 98                                  CBW                             ; CONVERT AL TO WORD
F21F 50                                  PUSH    AX                      ; SAVE PAGE VALUE
F220 F7E1                                MUL     CX                      ; DISPLAY PAGE TIMES REGEN LENGTH
F222 A34E00                              MOV     CRT_START,AX            ; SAVE START ADDRESS FOR
                                                                         ;  LATER REQUIREMENTS
F225 8BC8                                MOV     CX,AX                   ; START ADDRESS TO CX
F227 D1F9                                SAR     CX,1                    ; DIVIDE BY 2 FOR 6845 HANDLING
F229 B40C                                MOV     AH,12                   ; 6845 REGISTER FOR START ADDRESS
F22B E8AAFF                              CALL    M16
F22E 5B                                  POP     BX                      ; RECOVER PAGE VALUE
F22F D1E3                                SAL     BX,1                    ; *2 FOR WORD OFFSET
F231 8B4750                              MOV     AX,[BX + OFFSET CURSOR_POSN]    ; GET CURSOR FOR THIS PAGE
F234 E8CFFF                              CALL    M18                     ; SET THE CURSOR POSITION
F237 EB8C                                JMP     SHORT VIDEO_RETURN
                                 ACT_DISP_PAGE   ENDP
                                 ;--------------------------------------------------------------
                                 ; READ_CURSOR                                                 :
                                 ;       THIS ROUTINE READS THE CURRENT CURSOR VALUE FROM THE  :
                                 ;       6845, FORMATS IT, AND SENDS IT BACK TO THE CALLER     :
                                 ; INPUT                                                       :
                                 ;       BH - PAGE OF CURSOR                                   :
                                 ; OUTPUT                                                      :
                                 ;       DX - ROW, COLUMN OF THE CURRENT CURSOR POSITION       :
                                 ;       CX - CURRENT CURSOR MODE                              :
                                 ;--------------------------------------------------------------
F239                             READ_CURSOR     PROC    NEAR
F239 8ADF                                MOV     BL,BH
F23B 32FF                                XOR     BH,BH
F23D D1E3                                SAL     BX,1                    ; WORD OFFSET
```

```
LOC OBJ                 SOURCE

F23F 8B5750                     MOV     DX,[BX+OFFSET CURSOR_POSN]
F242 8B0E6000                   MOV     CX,CURSOR_MODE
F246 5F                         POP     DI
F247 5E                         POP     SI
F248 5B                         POP     BX
F249 58                         POP     AX                      ; DISCARD SAVED CX AND DX
F24A 58                         POP     AX
F24B 1F                         POP     DS
F24C 07                         POP     ES
F24D CF                         IRET
                        READ_CURSOR     ENDP
                        ;--------------------------------------------------------------------
                        ; SET COLOR                                                          :
                        ;       THIS ROUTINE WILL ESTABLISH THE BACKGROUND COLOR, THE OVERSCAN :
                        ;       COLOR, AND THE FOREGROUND COLOR SET FOR MEDIUM RESOLUTION    :
                        ;       GRAPHICS                                                     :
                        ; INPUT                                                              :
                        ;       (BH) HAS COLOR ID                                            :
                        ;               IF BH=0, THE BACKGROUND COLOR VALUE IS SET           :
                        ;                       FROM THE LOW BITS OF BL (0-31)               :
                        ;               IF BH=1, THE PALETTE SELECTION IS MADE               :
                        ;                       BASED ON THE LOW BIT OF BL:                  :
                        ;                               0=GREEN, RED, YELLOW FOR COLORS 1,2,3  :
                        ;                               1=BLUE, CYAN, MAGENTA FOR COLORS 1,2,3 :
                        ;       (BL) HAS THE COLOR VALUE TO BE USED                          :
                        ; OUTPUT                                                             :
                        ;       THE COLOR SELECTION IS UPDATED                               :
                        ;--------------------------------------------------------------------
F24E                    SET_COLOR       PROC    NEAR
F24E 8B166300                   MOV     DX,ADDR_6845            ; I/O PORT FOR PALETTE
F252 83C205                     ADD     DX,5                    ; OVERSCAN PORT
F255 A06600                     MOV     AL,CRT_PALETTE          ; GET THE CURRENT PALETTE VALUE
F258 0AFF                       OR      BH,BH                   ; IS THIS COLOR 0?
F25A 750E                       JNZ     M20                     ; OUTPUT COLOR 1

                        ;----- HANDLE COLOR 0 BY SETTING THE BACKGROUND COLOR

F25C 24E0                       AND     AL,0E0H                 ; TURN OFF LOW 5 BITS OF CURRENT
F25E 80E31F                     AND     BL,01FH                 ; TURN OFF HIGH 3 BITS OF INPUT VALUE
F261 0AC3                       OR      AL,BL                   ; PUT VALUE INTO REGISTER
F263                    M19:                                    ; OUTPUT THE PALETTE
F263 EE                         OUT     DX,AL                   ; OUTPUT COLOR SELECTION TO 3D9 PORT
F264 A26600                     MOV     CRT_PALETTE,AL          ; SAVE THE COLOR VALUE
F267 E95BFF                     JMP     VIDEO_RETURN

                        ;----- HANDLE COLOR 1 BY SELECTING THE PALETTE TO BE USED

F26A                    M20:
F26A 240F                       AND     AL,0DFH                 ; TURN OFF PALETTE SELECT BIT
F26C D0EB                       SHR     BL,1                    ; TEST THE LOW ORDER BIT OF BL
F26E 73F3                       JNC     M19                     ; ALREADY DONE
F270 0C20                       OR      AL,20H                  ; TURN ON PALETTE SELECT BIT
F272 EBEF                       JMP     M19                     ; GO DO IT
                        SET_COLOR       ENDP
                        ;----------------------------------------------
                        ; VIDEO STATE                                  :
                        ;  RETURNS THE CURRENT VIDEO STATE IN AX       :
                        ;  AH = NUMBER OF COLUMNS ON THE SCREEN        :
                        ;  AL = CURRENT VIDEO MODE                     :
                        ;  BH = CURRENT ACTIVE PAGE                    :
                        ;----------------------------------------------
F274                    VIDEO_STATE     PROC    NEAR
F274 8A264A00                   MOV     AH,BYTE PTR CRT_COLS    ; GET NUMBER OF COLUMNS
F278 A04900                     MOV     AL,CRT_MODE             ; CURRENT MODE
F27B 8A3E6200                   MOV     BH,ACTIVE_PAGE          ; GET CURRENT ACTIVE PAGE
F27F 5F                         POP     DI                      ; RECOVER REGISTERS
F280 5E                         POP     SI
F281 59                         POP     CX                      ; DISCARD SAVED BX
F282 E943FF                     JMP     M15                     ; RETURN TO CALLER
                        VIDEO_STATE     ENDP
                        ;------------------------------------------------------
                        ; POSITION                                             :
                        ;       THIS SERVICE ROUTINE CALCULATES THE REGEN      :
                        ;       BUFFER ADDRESS OF A CHARACTER IN THE ALPHA MODE :
                        ; INPUT                                                :
                        ;       AX = ROW, COLUMN POSITION                      :
                        ; OUTPUT                                               :
```

Section 5

```
LOC OBJ                LINE     SOURCE

                                ;       AX = OFFSET OF CHAR POSITION IN REGEN BUFFER    :
                                ;-------------------------------------------------------
F285                            POSITION        PROC    NEAR
F285 53                                 PUSH    BX                      ; SAVE REGISTER
F286 8BD8                               MOV     BX,AX
F288 8AC4                               MOV     AL,AH                   ; ROWS TO AL
F28A F6264A00                           MUL     BYTE PTR CRT_COLS       ; DETERMINE BYTES TO ROW
F28E 32FF                               XOR     BH,BH
F290 03C3                               ADD     AX,BX                   ; ADD IN COLUMN VALUE
F292 D1E0                               SAL     AX,1                    ; * 2 FOR ATTRIBUTE BYTES
F294 5B                                 POP     BX
F295 C3                                 RET
                                POSITION        ENDP
                                ;-------------------------------------------------------
                                ; SCROLL UP                                             :
                                ;       THIS ROUTINE MOVES A BLOCK OF CHARACTERS UP     :
                                ;       ON THE SCREEN                                   :
                                ; INPUT                                                 :
                                ;       (AH) = CURRENT CRT MODE                         :
                                ;       (AL) = NUMBER OF ROWS TO SCROLL                 :
                                ;       (CX) = ROW/COLUMN OF UPPER LEFT CORNER          :
                                ;       (DX) = ROW/COLUMN OF LOWER RIGHT CORNER         :
                                ;       (BH) = ATTRIBUTE TO BE USED ON BLANKED LINE     :
                                ;       (DS) = DATA SEGMENT                             :
                                ;       (ES) = REGEN BUFFER SEGMENT                     :
                                ; OUTPUT                                                :
                                ;       NONE -- THE REGEN BUFFER IS MODIFIED            :
                                ;-------------------------------------------------------
                                        ASSUME  CS:CODE,DS:DATA,ES:DATA
F296                            SCROLL_UP       PROC    NEAR
F296 8AD8                               MOV     BL,AL                   ; SAVE LINE COUNT IN BL
F298 80FC04                             CMP     AH,4                    ; TEST FOR GRAPHICS MODE
F29B 7208                               JC      N1                      ; HANDLE SEPARATELY
F29D 80FC07                             CMP     AH,7                    ; TEST FOR BW CARD
F2A0 7403                               JE      N1
F2A2 E9F001                             JMP     GRAPHICS_UP
F2A5                            N1:                                     ; UP_CONTINUE
F2A5 53                                 PUSH    BX                      ; SAVE FILL ATTRIBUTE IN BH
F2A6 8BC1                               MOV     AX,CX                   ; UPPER LEFT POSITION
F2A8 E83700                             CALL    SCROLL_POSITION         ; DO SETUP FOR SCROLL
F2AB 7431                               JZ      N7                      ; BLANK_FIELD
F2AD 03F0                               ADD     SI,AX                   ; FROM ADDRESS
F2AF 8AE6                               MOV     AH,DH                   ; # ROWS IN BLOCK
F2B1 2AE3                               SUB     AH,BL                   ; # ROWS TO BE MOVED
F2B3                            N2:                                     ; ROW_LOOP
F2B3 E87200                             CALL    N10                     ; MOVE ONE ROW
F2B6 03F5                               ADD     SI,BP
F2B8 03FD                               ADD     DI,BP                   ; POINT TO NEXT LINE IN BLOCK
F2BA FECC                               DEC     AH                      ; COUNT OF LINES TO MOVE
F2BC 75F5                               JNZ     N2                      ; ROW_LOOP
F2BE                            N3:                                     ; CLEAR_ENTRY
F2BE 58                                 POP     AX                      ; RECOVER ATTRIBUTE IN AH
F2BF B020                               MOV     AL,' '                  ; FILL WITH BLANKS
F2C1                            N4:                                     ; CLEAR_LOOP
F2C1 E86D00                             CALL    N11                     ; CLEAR THE ROW
F2C4 03FD                               ADD     DI,BP                   ; POINT TO NEXT LINE
F2C6 FECB                               DEC     BL                      ; COUNTER OF LINES TO SCROLL
F2C8 75F7                               JNZ     N4                      ; CLEAR_LOOP
F2CA                            N5:                                     ; SCROLL_END
F2CA E8710C                             CALL    DDS
F2CD 803E490007                         CMP     CRT_MODE,7              ; IS THIS THE BLACK AND WHITE CARD
F2D2 7407                               JE      N6                      ; IF SO, SKIP THE MODE RESET
F2D4 A06500                             MOV     AL,CRT_MODE_SET         ; GET THE VALUE OF THE MODE SET
F2D7 BAD803                             MOV     DX,03D8H                ; ALWAYS SET COLOR CARD PORT
F2DA EE                                 OUT     DX,AL
F2DB                            N6:                                     ; VIDEO_RET_HERE
F2DB E9E7FE                             JMP     VIDEO_RETURN
F2DE                            N7:                                     ; BLANK_FIELD
F2DE 8ADE                               MOV     BL,DH                   ; GET ROW COUNT
F2E0 EBDC                               JMP     N3                      ; GO CLEAR THAT AREA
                                SCROLL_UP       ENDP

                                ;----- HANDLE COMMON SCROLL SET UP HERE

F2E2                            SCROLL_POSITION PROC    NEAR
F2E2 803E490002                         CMP     CRT_MODE,2              ; TEST FOR SPECIAL CASE HERE
F2E7 7218                               JB      N9                      ; HAVE TO HANDLE 80X25 SEPARATELY
```

```
LOC OBJ                     SOURCE

F2E9 803E490003                     CMP     CRT_MODE,3
F2EE 7711                           JA      N9

                            ;----- 80X25 COLOR CARD SCROLL

F2F0 52                             PUSH    DX
F2F1 BADA03                         MOV     DX,3DAH             ; GUARANTEED TO BE COLOR CARD HERE
F2F4 50                             PUSH    AX
F2F5                        N8:                                 ; WAIT_DISP_ENABLE
F2F5 EC                             IN      AL,DX               ; GET PORT
F2F6 A808                           TEST    AL,8                ; WAIT FOR VERTICAL RETRACE
F2F8 74FB                           JZ      N8                  ; WAIT_DISP_ENABLE
F2FA B025                           MOV     AL,25H
F2FC B2D8                           MOV     DL,0D8H             ; DX=3D8
F2FE EE                             OUT     DX,AL               ; TURN OFF VIDEO
F2FF 58                             POP     AX                  ; DURING VERTICAL RETRACE
F300 5A                             POP     DX
F301                        N9:
F301 E881FF                         CALL    POSITION            ; CONVERT TO REGEN POINTER
F304 03064E00                       ADD     AX,CRT_START        ; OFFSET OF ACTIVE PAGE
F308 8BF8                           MOV     DI,AX               ; TO ADDRESS FOR SCROLL
F30A 8BF0                           MOV     SI,AX               ; FROM ADDRESS FOR SCROLL
F30C 2BD1                           SUB     DX,CX               ; DX = #ROWS, #COLS IN BLOCK
F30E FEC6                           INC     DH
F310 FEC2                           INC     DL                  ; INCREMENT FOR 0 ORIGIN
F312 32ED                           XOR     CH,CH               ; SET HIGH BYTE OF COUNT TO ZERO
F314 8B2E4A00                       MOV     BP,CRT_COLS         ; GET NUMBER OF COLUMNS IN DISPLAY
F318 03ED                           ADD     BP,BP               ; TIMES 2 FOR ATTRIBUTE BYTE
F31A 8AC3                           MOV     AL,BL               ; GET LINE COUNT
F31C F6264A00                       MUL     BYTE PTR CRT_COLS   ; DETERMINE OFFSET TO FROM ADDRESS
F320 03C0                           ADD     AX,AX               ; *2 FOR ATTRIBUTE BYTE
F322 06                             PUSH    ES                  ; ESTABLISH ADDRESSING TO REGEN BUFFER
F323 1F                             POP     DS                  ;  FOR BOTH POINTERS
F324 80FB00                         CMP     BL,0                ; 0 SCROLL MEANS BLANK FIELD
F327 C3                             RET                         ; RETURN WITH FLAGS SET
                            SCROLL_POSITION ENDP

                            ;----- MOVE_ROW

F328                        N10     PROC    NEAR
F328 8ACA                           MOV     CL,DL               ; GET # OF COLS TO MOVE
F32A 56                             PUSH    SI
F32B 57                             PUSH    DI                  ; SAVE START ADDRESS
F32C F3                             REP     MOVSW               ; MOVE THAT LINE ON SCREEN
F32D A5
F32E 5F                             POP     DI
F32F 5E                             POP     SI                  ; RECOVER ADDRESSES
F330 C3                             RET
                            N10     ENDP

                            ;----- CLEAR_ROW

F331                        N11     PROC    NEAR
F331 8ACA                           MOV     CL,DL               ; GET # COLUMNS TO CLEAR
F333 57                             PUSH    DI
F334 F3                             REP     STOSW               ; STORE THE FILL CHARACTER
F335 AB
F336 5F                             POP     DI
F337 C3                             RET
                            N11     ENDP
                            ;--------------------------------------------------------
                            ; SCROLL_DOWN                                           :
                            ;       THIS ROUTINE MOVES THE CHARACTERS WITHIN A      :
                            ;       DEFINED BLOCK DOWN ON THE SCREEN, FILLING THE   :
                            ;       TOP LINES WITH A DEFINED CHARACTER              :
                            ; INPUT                                                 :
                            ;       (AH) = CURRENT CRT MODE                         :
                            ;       (AL) = NUMBER OF LINES TO SCROLL                :
                            ;       (CX) = UPPER LEFT CORNER OF REGION              :
                            ;       (DX) = LOWER RIGHT CORNER OF REGION             :
                            ;       (BH) = FILL CHARACTER                           :
                            ;       (DS) = DATA SEGMENT                             :
                            ;       (ES) = REGEN SEGMENT                            :
                            ; OUTPUT                                                :
                            ;       NONE -- SCREEN IS SCROLLED                      :
                            ;--------------------------------------------------------
F338                        SCROLL_DOWN     PROC    NEAR
```

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LOC OBJ              SOURCE

F338 FD                      STD                        ; DIRECTION FOR SCROLL DOWN
F339 8AD8                    MOV     BL,AL              ; LINE COUNT TO BL
F33B 80FC04                  CMP     AH,4               ; TEST FOR GRAPHICS
F33E 7208                    JC      N12
F340 80FC07                  CMP     AH,7               ; TEST FOR BW CARD
F343 7403                    JE      N12
F345 E9A601                  JMP     GRAPHICS_DOWN
F348                 N12:                               ; CONTINUE DOWN
F348 53                      PUSH    BX                 ; SAVE ATTRIBUTE IN BH
F349 8BC2                    MOV     AX,DX              ; LOWER RIGHT CORNER
F34B E894FF                  CALL    SCROLL_POSITION    ; GET REGEN LOCATION
F34E 7420                    JZ      N16
F350 2BF0                    SUB     SI,AX              ; SI IS FROM ADDRESS
F352 8AE6                    MOV     AH,DH              ; GET TOTAL # ROWS
F354 2AE3                    SUB     AH,BL              ; COUNT TO MOVE IN SCROLL
F356                 N13:
F356 E8CFFF                  CALL    N10                ; MOVE ONE ROW
F359 2BF5                    SUB     SI,BP
F35B 2BFD                    SUB     DI,BP
F35D FECC                    DEC     AH
F35F 75F5                    JNZ     N13
F361                 N14:
F361 58                      POP     AX                 ; RECOVER ATTRIBUTE IN AH
F362 B020                    MOV     AL,' '
F364                 N15:
F364 E8CAFF                  CALL    N11                ; CLEAR ONE ROW
F367 2BFD                    SUB     DI,BP              ; GO TO NEXT ROW
F369 FECB                    DEC     BL
F36B 75F7                    JNZ     N15
F36D E95AFF                  JMP     N5                 ; SCROLL_END
F370                 N16:
F370 8ADE                    MOV     BL,DH
F372 EBED                    JMP     N14
                     SCROLL_DOWN     ENDP
                     ;-------------------------------------------------------
                     ; READ_AC_CURRENT                                      :
                     ;       THIS ROUTINE READS THE ATTRIBUTE AND CHARACTER  :
                     ;       AT THE CURRENT CURSOR POSITION AND RETURNS THEM :
                     ;       TO THE CALLER                                   :
                     ;INPUT                                                 :
                     ;       (AH) = CURRENT CRT MODE                         :
                     ;       (BH) = DISPLAY PAGE ( ALPHA MODES ONLY )        :
                     ;       (DS) = DATA SEGMENT                             :
                     ;       (ES) = REGEN SEGMENT                            :
                     ;OUTPUT                                                :
                     ;       (AL) = CHAR READ                                :
                     ;       (AH) = ATTRIBUTE READ                           :
                     ;-------------------------------------------------------
                             ASSUME  CS:CODE,DS:DATA,ES:DATA
F374                 READ_AC_CURRENT PROC     NEAR
F374 80FC04                  CMP     AH,4               ; IS THIS GRAPHICS
F377 7208                    JC      P1
F379 80FC07                  CMP     AH,7               ; IS THIS BW CARD
F37C 7403                    JE      P1
F37E E9A802                  JMP     GRAPHICS_READ
F381                 P1:                                ; READ_AC_CONTINUE
F381 E81A00                  CALL    FIND_POSITION
F384 8BF3                    MOV     SI,BX              ; ESTABLISH ADDRESSING IN SI

                     ;----- WAIT FOR HORIZONTAL RETRACE

F386 8B166300                MOV     DX,ADDR_6845       ; GET BASE ADDRESS
F38A 83C206                  ADD     DX,6               ; POINT AT STATUS PORT
F38D 06                      PUSH    ES
F38E 1F                      POP     DS                 ; GET SEGMENT FOR QUICK ACCESS
F38F                 P2:                                ; WAIT FOR RETRACE LOW
F38F EC                      IN      AL,DX              ; GET STATUS
F390 A801                    TEST    AL,1               ; IS HORZ RETRACE LOW
F392 75FB                    JNZ     P2                 ; WAIT UNTIL IT IS
F394 FA                      CLI                        ; NO MORE INTERRUPTS
F395                 P3:                                ; WAIT FOR RETRACE HIGH
F395 EC                      IN      AL,DX              ; GET STATUS
F396 A801                    TEST    AL,1               ; IS IT HIGH
F398 74FB                    JZ      P3                 ; WAIT UNTIL IT IS
F39A AD                      LODSW                      ; GET THE CHAR/ATTR
F39B E927FE                  JMP     VIDEO_RETURN
                     READ_AC_CURRENT ENDP
```

```
LOC OBJ                 SOURCE

F39E                    FIND_POSITION   PROC    NEAR
F39E 8ACF                       MOV     CL,BH                   ; DISPLAY PAGE TO CX
F3A0 32ED                       XOR     CH,CH
F3A2 8BF1                       MOV     SI,CX                   ; MOVE TO SI FOR INDEX
F3A4 D1E6                       SAL     SI,1                    ; * 2 FOR WORD OFFSET
F3A6 8B4450                     MOV     AX,[SI+ OFFSET CURSOR_POSN]     ; GET ROW/COLUMN OF THAT PAGE
F3A9 33DB                       XOR     BX,BX                   ; SET START ADDRESS TO ZERO
F3AB E306                       JCXZ    P5                      ; NO_PAGE
F3AD                    P4:                                     ; PAGE_LOOP
F3AD 031E4C00                   ADD     BX,CRT_LEN              ; LENGTH OF BUFFER
F3B1 E2FA                       LOOP    P4
F3B3                    P5:                                     ; NO_PAGE
F3B3 E8CFFE                     CALL    POSITION                ; DETERMINE LOCATION IN REGEN
F3B6 03D8                       ADD     BX,AX                   ; ADD TO START OF REGEN
F3B8 C3                         RET
                        FIND_POSITION   ENDP
                        ;----------------------------------------------
                        ; WRITE_AC_CURRENT                              :
                        ;       THIS ROUTINE WRITES THE ATTRIBUTE       :
                        ;       AND CHARACTER AT THE CURRENT CURSOR     :
                        ;       POSITION                                :
                        ; INPUT                                         :
                        ;       (AH) = CURRENT CRT MODE                 :
                        ;       (BH) = DISPLAY PAGE                     :
                        ;       (CX) = COUNT OF CHARACTERS TO WRITE     :
                        ;       (AL) = CHAR TO WRITE                    :
                        ;       (BL) = ATTRIBUTE OF CHAR TO WRITE       :
                        ;       (DS) = DATA SEGMENT                     :
                        ;       (ES) = REGEN SEGMENT                    :
                        ; OUTPUT                                        :
                        ;       NONE                                    :
                        ;----------------------------------------------
F3B9                    WRITE_AC_CURRENT        PROC    NEAR
F3B9 80FC04                     CMP     AH,4                    ; IS THIS GRAPHICS
F3BC 7208                       JC      P6
F3BE 80FC07                     CMP     AH,7                    ; IS THIS BW CARD
F3C1 7403                       JE      P6
F3C3 E9B201                     JMP     GRAPHICS_WRITE
F3C6                    P6:                                     ; WRITE_AC_CONTINUE
F3C6 8AE3                       MOV     AH,BL                   ; GET ATTRIBUTE TO AH
F3C8 50                         PUSH    AX                      ; SAVE ON STACK
F3C9 51                         PUSH    CX                      ; SAVE WRITE COUNT
F3CA E8D1FF                     CALL    FIND_POSITION
F3CD 8BFB                       MOV     DI,BX                   ; ADDRESS TO DI REGISTER
F3CF 59                         POP     CX                      ; WRITE COUNT
F3D0 5B                         POP     BX                      ; CHARACTER IN BX REG
F3D1                    P7:                                     ; WRITE_LOOP

                        ;----- WAIT FOR HORIZONTAL RETRACE

F3D1 8B166300                   MOV     DX,ADDR_6845            ; GET BASE ADDRESS
F3D5 83C206                     ADD     DX,6                    ; POINT AT STATUS PORT
F3D8                    P8:
F3D8 EC                         IN      AL,DX                   ; GET STATUS
F3D9 A801                       TEST    AL,1                    ; IS IT LOW
F3DB 75FB                       JNZ     P8                      ; WAIT UNTIL IT IS
F3DD FA                         CLI                             ; NO MORE INTERRUPTS
F3DE                    P9:
F3DE EC                         IN      AL,DX                   ; GET STATUS
F3DF A801                       TEST    AL,1                    ; IS IT HIGH
F3E1 74FB                       JZ      P9                      ; WAIT UNTIL IT IS
F3E3 8BC3                       MOV     AX,BX                   ; RECOVER THE CHAR/ATTR
F3E5 AB                         STOSW                           ; PUT THE CHAR/ATTR
F3E6 FB                         STI                             ; INTERRUPTS BACK ON
F3E7 E2E8                       LOOP    P7                      ;  AS MANY TIMES AS REQUESTED
F3E9 E9D9FD                     JMP     VIDEO_RETURN
                        WRITE_AC_CURRENT        ENDP
                        ;----------------------------------------------
                        ; WRITE_C_CURRENT                               :
                        ;       THIS ROUTINE WRITES THE CHARACTER AT    :
                        ;       THE CURRENT CURSOR POSITION, ATTRIBUTE  :
                        ;       UNCHANGED                               :
                        ; INPUT                                         :
                        ;       (AH) = CURRENT CRT MODE                 :
                        ;       (BH) = DISPLAY PAGE                     :
                        ;       (CX) = COUNT OF CHARACTERS TO WRITE     :
```

```
LOC OBJ                 SOURCE

                        ;       (AL) = CHAR TO WRITE                :
                        ;       (DS) = DATA SEGMENT                 :
                        ;       (ES) = REGEN SEGMENT                :
                        ; OUTPUT                                    :
                        ;       NONE                                :
                        ;--------------------------------------------
F3EC                    WRITE_C_CURRENT PROC    NEAR
F3EC 80FC04                     CMP     AH,4                    ; IS THIS GRAPHICS
F3EF 7208                       JC      P10
F3F1 80FC07                     CMP     AH,7                    ; IS THIS BW CARD
F3F4 7403                       JE      P10
F3F6 E97F01                     JMP     GRAPHICS_WRITE
F3F9                    P10:
F3F9 50                         PUSH    AX                      ; SAVE ON STACK
F3FA 51                         PUSH    CX                      ; SAVE WRITE COUNT
F3FB E8A0FF                     CALL    FIND_POSITION
F3FE 8BFB                       MOV     DI,BX                   ; ADDRESS TO DI
F400 59                         POP     CX                      ; WRITE COUNT
F401 5B                         POP     BX                      ; BL HAS CHAR TO WRITE
F402                    P11:                                    ; WRITE_LOOP

                        ;----- WAIT FOR HORIZONTAL RETRACE

F402 8B166300                   MOV     DX,ADDR_6845            ; GET BASE ADDRESS
F406 83C206                     ADD     DX,6                    ; POINT AT STATUS PORT
F409                    P12:
F409 EC                         IN      AL,DX                   ; GET STATUS
F40A A801                       TEST    AL,1                    ; IS IT LOW
F40C 75FB                       JNZ     P12                     ; WAIT UNTIL IT IS
F40E FA                         CLI                             ; NO MORE INTERRUPTS
F40F                    P13:
F40F EC                         IN      AL,DX                   ; GET STATUS
F410 A801                       TEST    AL,1                    ; IS IT HIGH
F412 74FB                       JZ      P13                     ; WAIT UNTIL IT IS
F414 8AC3                       MOV     AL,BL                   ; RECOVER CHAR
F416 AA                         STOSB                           ; PUT THE CHAR/ATTR
F417 FB                         STI                             ; INTERRUPTS BACK ON
F418 47                         INC     DI                      ; BUMP POINTER PAST ATTRIBUTE
F419 E2E7                       LOOP    P11                     ;  AS MANY TIMES AS REQUESTED
F41B E9A7FD                     JMP     VIDEO_RETURN
                        WRITE_C_CURRENT ENDP
                        ;------------------------------------------------------------
                        ; READ DOT  -- WRITE DOT                                     :
                        ;       THESE ROUTINES WILL WRITE A DOT, OR READ THE DOT AT  :
                        ;       THE INDICATED LOCATION                               :
                        ; ENTRY --                                                   :
                        ;   DX = ROW (0-199)    (THE ACTUAL VALUE DEPENDS ON THE MODE) :
                        ;   CX = COLUMN ( 0-639) ( THE VALUES ARE NOT RANGE CHECKED )  :
                        ;   AL = DOT VALUE TO WRITE (1,2 OR 4 BITS DEPENDING ON MODE,  :
                        ;       REQ'D FOR WRITE DOT ONLY, RIGHT JUSTIFIED)           :
                        ;       BIT 7 OF AL=1 INDICATES XOR THE VALUE INTO THE LOCATION :
                        ;   DS = DATA SEGMENT                                        :
                        ;   ES = REGEN SEGMENT                                       :
                        ;                                                            :
                        ; EXIT                                                       :
                        ;       AL = DOT VALUE READ, RIGHT JUSTIFIED, READ ONLY      :
                        ;------------------------------------------------------------
                                ASSUME  CS:CODE,DS:DATA,ES:DATA
F41E                    READ_DOT        PROC    NEAR
F41E E83100                     CALL    R3                      ; DETERMINE BYTE POSITION OF DOT
F421 268A04                     MOV     AL,ES:[SI]              ; GET THE BYTE
F424 22C4                       AND     AL,AH                   ; MASK OFF THE OTHER BITS IN THE BYTE
F426 D2E0                       SHL     AL,CL                   ; LEFT JUSTIFY THE VALUE
F428 8ACE                       MOV     CL,DH                   ; GET NUMBER OF BITS IN RESULT
F42A D2C0                       ROL     AL,CL                   ; RIGHT JUSTIFY THE RESULT
F42C E996FD                     JMP     VIDEO_RETURN            ; RETURN FROM VIDEO IO
                        READ_DOT        ENDP

F42F                    WRITE_DOT       PROC    NEAR
F42F 50                         PUSH    AX                      ; SAVE DOT VALUE
F430 50                         PUSH    AX                      ;  TWICE
F431 E81E00                     CALL    R3                      ; DETERMINE BYTE POSITION OF THE DOT
F434 D2E8                       SHR     AL,CL                   ; SHIFT TO SET UP THE BITS FOR OUTPUT
F436 22C4                       AND     AL,AH                   ; STRIP OFF THE OTHER BITS
F438 268A0C                     MOV     CL,ES:[SI]              ; GET THE CURRENT BYTE
F43B 5B                         POP     BX                      ; RECOVER XOR FLAG
F43C F6C380                     TEST    BL,80H                  ; IS IT ON
```

```
LOC OBJ                SOURCE

F43F 750D                      JNZ     R2                      ; YES, XOR THE DOT
F441 F6D4                      NOT     AH                      ; SET THE MASK TO REMOVE THE
F443 22CC                      AND     CL,AH                   ;  INDICATED BITS
F445 0AC1                      OR      AL,CL                   ; OR IN THE NEW VALUE OF THOSE BITS
F447                   R1:                                     ; FINISH_DOT
F447 268804                    MOV     ES:[SI],AL              ; RESTORE THE BYTE IN MEMORY
F44A 58                        POP     AX
F44B E977FD                    JMP     VIDEO_RETURN            ; RETURN FROM VIDEO IO
F44E                   R2:                                     ; XOR_DOT
F44E 32C1                      XOR     AL,CL                   ; EXCLUSIVE OR THE DOTS
F450 EBF5                      JMP     R1                      ; FINISH UP THE WRITING
                       WRITE_DOT       ENDP
                       ;------------------------------------------------------
                       ; THIS SUBROUTINE DETERMINES THE REGEN BYTE LOCATION    :
                       ; OF THE INDICATED ROW COLUMN VALUE IN GRAPHICS MODE.   :
                       ; ENTRY --                                              :
                       ;  DX = ROW VALUE (0-199)                               :
                       ;  CX = COLUMN VALUE (0-639)                            :
                       ; EXIT --                                               :
                       ;  SI = OFFSET INTO REGEN BUFFER FOR BYTE OF INTEREST   :
                       ;  AH = MASK TO STRIP OFF THE BITS OF INTEREST          :
                       ;  CL = BITS TO SHIFT TO RIGHT JUSTIFY THE MASK IN AH   :
                       ;  DH = # BITS IN RESULT                                :
                       ;------------------------------------------------------
F452                   R3      PROC    NEAR
F452 53                        PUSH    BX                      ; SAVE BX DURING OPERATION
F453 50                        PUSH    AX                      ; WILL SAVE AL DURING OPERATION

                       ;----- DETERMINE 1ST BYTE IN IDICATED ROW BY MULTIPLYING ROW VALUE BY 40
                       ;----- ( LOW BIT OF ROW DETERMINES EVEN/ODD, 80 BYTES/ROW

F454 B028                      MOV     AL,40
F456 52                        PUSH    DX                      ; SAVE ROW VALUE
F457 80E2FE                    AND     DL,0FEH                 ; STRIP OFF ODD/EVEN BIT
F45A F6E2                      MUL     DL                      ; AX HAS ADDRESS OF 1ST BYTE
                                                               ;  OF INDICATED ROW
F45C 5A                        POP     DX                      ; RECOVER IT
F45D F6C201                    TEST    DL,1                    ; TEST FOR EVEN/ODD
F460 7403                      JZ      R4                      ; JUMP IF EVEN ROW
F462 050020                    ADD     AX,2000H                ; OFFSET TO LOCATION OF ODD ROWS
F465                   R4:                                     ; EVEN_ROW
F465 8BF0                      MOV     SI,AX                   ; MOVE POINTER TO SI
F467 58                        POP     AX                      ; RECOVER AL VALUE
F468 8BD1                      MOV     DX,CX                   ; COLUMN VALUE TO DX

                       ;----- DETERMINE GRAPHICS MODE CURRENTLY IN EFFECT

                       ;-----------------------------------------------------------------
                       ; SET UP THE REGISTERS ACCORDING TO THE MODE                      :
                       ;  CH = MASK FOR LOW OF COLUMN ADDRESS ( 7/3 FOR HIGH/MED RES)    :
                       ;  CL = # OF ADDRESS BITS IN COLUMN VALUE ( 3/2 FOR H/M)          :
                       ;  BL = MASK TO SELECT BITS FROM POINTED BYTE (80H/C0H FOR H/M)   :
                       ;  BH = NUMBER OF VALID BITS IN POINTED BYTE ( 1/2 FOR H/M)       :
                       ;-----------------------------------------------------------------

F46A BBC002                    MOV     BX,2C0H
F46D B90203                    MOV     CX,302H                 ; SET PARMS FOR MED RES
F470 803E490006                CMP     CRT_MODE,6
F475 7206                      JC      R5                      ; HANDLE IF MED ARES
F477 BB8001                    MOV     BX,180H
F47A B90307                    MOV     CX,703H                 ; SET PARMS FOR HIGH RES

                       ;----- DETERMINE BIT OFFSET IN BYTE FROM COLUMN MASK

F47D                   R5:
F47D 22EA                      AND     CH,DL                   ; ADDRESS OF PEL WITHIN BYTE TO CH

                       ;----- DETERMINE BYTE OFFSET FOR THIS LOCATION IN COLUMN

F47F D3EA                      SHR     DX,CL                   ; SHIFT BY CORRECT AMOUNT
F481 03F2                      ADD     SI,DX                   ; INCREMENT THE POINTER
F483 8AF7                      MOV     DH,BH                   ; GET THE # OF BITS IN RESULT TO DH

                       ;----- MULTIPLY BH (VALID BITS IN BYTE) BY CH (BIT OFFSET)

F485 2AC9                      SUB     CL,CL                   ; ZERO INTO STORAGE LOCATION
F487                   R6:
```

```
LOC OBJ                 LINE    SOURCE

F487 D0C8                               ROR     AL,1                    ; LEFT JUSTIFY THE VALUE
                                                                        ;  IN AL (FOR WRITE)
F489 02CD                               ADD     CL,CH                   ; ADD IN THE BIT OFFSET VALUE
F48B FECF                               DEC     BH                      ; LOOP CONTROL
F48D 75F8                               JNZ     R6                      ; ON EXIT, CL HAS SHIFT COUNT
                                                                        ;  TO RESTORE BITS
F48F 8AE3                               MOV     AH,BL                   ; GET MASK TO AH
F491 D2EC                               SHR     AH,CL                   ; MOVE THE MASK TO CORRECT LOCATION
F493 5B                                 POP     BX                      ; RECOVER REG
F494 C3                                 RET                             ; RETURN WITH EVERYTHING SET UP
                                R3      ENDP
                                ;--------------------------------------------------------------
                                ; SCROLL UP                                                   :
                                ;       THIS ROUTINE SCROLLS UP THE INFORMATION ON THE CRT    :
                                ; ENTRY                                                       :
                                ;       CH,CL = UPPER LEFT CORNER OF REGION TO SCROLL         :
                                ;       DH,DL = LOWER RIGHT CORNER OF REGION TO SCROLL        :
                                ;        BOTH OF THE ABOVE ARE IN CHARACTER POSITIONS         :
                                ;       BH = FILL VALUE FOR BLANKED LINES                     :
                                ;       AL = # LINES TO SCROLL (AL=0 MEANS BLANK THE ENTIRE   :
                                ;            FIELD)                                           :
                                ;       DS = DATA SEGMENT                                     :
                                ;       ES = REGEN SEGMENT                                    :
                                ; EXIT                                                        :
                                ;       NOTHING, THE SCREEN IS SCROLLED                       :
                                ;--------------------------------------------------------------
F495                            GRAPHICS_UP     PROC    NEAR
F495 8AD8                               MOV     BL,AL                   ; SAVE LINE COUNT IN BL
F497 8BC1                               MOV     AX,CX                   ; GET UPPER LEFT POSITION INTO AX REG

                                ;----- USE CHARACTER SUBROUTINE FOR POSITIONING
                                ;----- ADDRESS RETURNED IS MULTIPLIED BY 2 FROM CORRECT VALUE

F499 E86902                             CALL    GRAPH_POSN
F49C 8BF8                               MOV     DI,AX                   ; SAVE RESULT AS DESTINATION ADDRESS

                                ;----- DETERMINE SIZE OF WINDOW

F49E 2BD1                               SUB     DX,CX
F4A0 81C20101                           ADD     DX,101H                 ; ADJUST VALUES
F4A4 D0E6                               SAL     DH,1                    ; MULTIPLY # ROWS BY 4
                                                                        ;  SINCE 8 VERT DOTS/CHAR
F4A6 D0E6                               SAL     DH,1                    ;  AND EVEN/ODD ROWS

                                ;----- DETERMINE CRT MODE

F4A8 803E490006                         CMP     CRT_MODE,6              ; TEST FOR MEDIUM RES
F4AD 7304                               JNC     R7                      ; FIND_SOURCE

                                ;----- MEDIUM RES UP

F4AF D0E2                               SAL     DL,1                    ; # COLUMNS * 2, SINCE 2 BYTES/CHAR
F4B1 D1E7                               SAL     DI,1                    ; OFFSET *2 SINCE 2 BYTES/CHAR

                                ;----- DETERMINE THE SOURCE ADDRESS IN THE BUFFER

F4B3                            R7:                                     ; FIND_SOURCE
F4B3 06                                 PUSH    ES                      ; GET SEGMENTS BOTH POINTING TO REGEN
F4B4 1F                                 POP     DS
F4B5 2AED                               SUB     CH,CH                   ; ZERO TO HIGH OF COUNT REG
F4B7 D0E3                               SAL     BL,1                    ; MULTIPLY NUMBER OF LINES BY 4
F4B9 D0E3                               SAL     BL,1
F4BB 742D                               JZ      R11                     ; IF ZERO, THEN BLANK ENTIRE FIELD
F4BD 8AC3                               MOV     AL,BL                   ; GET NUMBER OF LINES IN AL
F4BF B450                               MOV     AH,80                   ; 80 BYTES/ROW
F4C1 F6E4                               MUL     AH                      ; DETERMINE OFFSET TO SOURCE
F4C3 8BF7                               MOV     SI,DI                   ; SET UP SOURCE
F4C5 03F0                               ADD     SI,AX                   ;  ADD IN OFFSET TO IT
F4C7 8AE6                               MOV     AH,DH                   ; NUMBER OF ROWS IN FIELD
F4C9 2AE3                               SUB     AH,BL                   ; DETERMINE NUMBER TO MOVE

                                ;----- LOOP THROUGH, MOVING ONE ROW AT A TIME, BOTH EVEN AND ODD FIELDS

F4CB                            R8:                                     ; ROW_LOOP
F4CB E88000                             CALL    R17                     ; MOVE ONE ROW
F4CE 81EEB01F                           SUB     SI,2000H-80             ; MOVE TO NEXT ROW
F4D2 81EFB01F                           SUB     DI,2000H-80
```

```
LOC OBJ                SOURCE

F4D6 FECC                      DEC     AH                       ; NUMBER OF ROWS TO MOVE
F4D8 75F1                      JNZ     R8                       ; CONTINUE TILL ALL MOVED
                       ;----- FILL IN THE VACATED LINE(S)
F4DA                   R9:                                      ; CLEAR_ENTRY
F4DA 8AC7                      MOV     AL,BH                    ; ATTRIBUTE TO FILL WITH
F4DC                   R10:
F4DC E88800                    CALL    R18                      ; CLEAR THAT ROW
F4DF 81EFB01F                  SUB     DI,2000H-80              ; POINT TO NEXT LINE
F4E3 FECB                      DEC     BL                       ; NUMBER OF LINES TO FILL
F4E5 75F5                      JNZ     R10                      ; CLEAR_LOOP
F4E7 E9DBFC                    JMP     VIDEO_RETURN             ; EVERYTHING DONE
F4EA                   R11:                                     ; BLANK_FIELD
F4EA 8ADE                      MOV     BL,DH                    ; SET BLANK COUNT TO
                                                                ;  EVERYTHING IN FIELD
F4EC EBEC                      JMP     R9                       ; CLEAR THE FIELD
                       GRAPHICS_UP     ENDP
                       ;-------------------------------------------------------------
                       ; SCROLL DOWN                                                 :
                       ;       THIS ROUTINE SCROLLS DOWN THE INFORMATION ON THE CRT  :
                       ; ENTRY                                                       :
                       ;       CH,CL = UPPER LEFT CORNER OF REGION TO SCROLL         :
                       ;       DH,DL = LOWER RIGHT CORNER OF REGION TO SCROLL        :
                       ;        BOTH OF THE ABOVE ARE IN CHARACTER POSITIONS         :
                       ;       BH = FILL VALUE FOR BLANKED LINES                     :
                       ;       AL = # LINES TO SCROLL (AL=0 MEANS BLANK THE ENTIRE   :
                       ;            FIELD)                                           :
                       ;       DS = DATA SEGMENT                                     :
                       ;       ES = REGEN SEGMENT                                    :
                       ; EXIT                                                        :
                       ;       NOTHING, THE SCREEN IS SCROLLED                       :
                       ;-------------------------------------------------------------
F4EE                   GRAPHICS_DOWN   PROC    NEAR
F4EE FD                        STD                              ; SET DIRECTION
F4EF 8AD8                      MOV     BL,AL                    ; SAVE LINE COUNT IN BL
F4F1 8BC2                      MOV     AX,DX                    ; GET LOWER RIGHT POSITION INTO AX REG
                       ;----- USE CHARACTER SUBROUTINE FOR POSITIONING
                       ;----- ADDRESS RETURNED IS MULTIPLIED BY 2 FROM CORRECT VALUE
F4F3 E80F02                    CALL    GRAPH_POSN
F4F6 8BF8                      MOV     DI,AX                    ; SAVE RESULT AS DESTINATION ADDRESS
                       ;----- DETERMINE SIZE OF WINDOW
F4F8 2BD1                      SUB     DX,CX
F4FA 81C20101                  ADD     DX,101H                  ; ADJUST VALUES
F4FE D0E6                      SAL     DH,1                     ; MULTIPLY # ROWS BY 4
                                                                ;  SINCE 8 VERT DOTS/CHAR
F500 D0E6                      SAL     DH,1                     ;  AND EVEN/ODD ROWS
                       ;----- DETERMINE CRT MODE
F502 803E490006                CMP     CRT_MODE,6               ; TEST FOR MEDIUM RES
F507 7305                      JNC     R12                      ; FIND_SOURCE_DOWN
                       ;----- MEDIUM RES DOWN
F509 D0E2                      SAL     DL,1                     ; # COLUMNS * 2, SINCE
                                                                ;  2 BYTES/CHAR (OFFSET OK)
F50B D1E7                      SAL     DI,1                     ; OFFSET *2 SINCE 2 BYTES/CHAR
F50D 47                        INC     DI                       ; POINT TO LAST BYTE
                       ;----- DETERMINE THE SOURCE ADDRESS IN THE BUFFER
F50E                   R12:                                     ; FIND_SOURCE_DOWN
F50E 06                        PUSH    ES                       ; BOTH SEGMENTS TO REGEN
F50F 1F                        POP     DS
F510 2AED                      SUB     CH,CH                    ; ZERO TO HIGH OF COUNT REG
F512 81C7F000                  ADD     DI,240                   ; POINT TO LAST ROW OF PIXELS
F516 D0E3                      SAL     BL,1                     ; MULTIPLY NUMBER OF LINES BY 4
F518 D0E3                      SAL     BL,1
F51A 742E                      JZ      R16                      ; IF ZERO, THEN BLANK ENTIRE FIELD
F51C 8AC3                      MOV     AL,BL                    ; GET NUMBER OF LINES IN AL
F51E B450                      MOV     AH,80                    ; 80 BYTES/ROW
F520 F6E4                      MUL     AH                       ; DETERMINE OFFSET TO SOURCE
```

Section 5

```
LOC OBJ                  SOURCE

F522 8BF7                        MOV     SI,DI                   ; SET UP SOURCE
F524 2BF0                        SUB     SI,AX                   ;  SUBTRACT THE OFFSET
F526 8AE6                        MOV     AH,DH                   ; NUMBER OF ROWS IN FIELD
F528 2AE3                        SUB     AH,BL                   ; DETERMINE NUMBER TO MOVE

                         ;----- LOOP THROUGH, MOVING ONE ROW AT A TIME, BOTH EVEN AND ODD FIELDS

F52A                     R13:                                    ; ROW_LOOP_DOWN
F52A E82100                      CALL    R17                     ; MOVE ONE ROW
F52D 81EE5020                    SUB     SI,2000H+80             ; MOVE TO NEXT ROW
F531 81EF5020                    SUB     DI,2000H+80
F535 FECC                        DEC     AH                      ; NUMBER OF ROWS TO MOVE
F537 75F1                        JNZ     R13                     ; CONTINUE TILL ALL MOVED

                         ;----- FILL IN THE VACATED LINE(S)

F539                     R14:                                    ; CLEAR_ENTRY_DOWN
F539 8AC7                        MOV     AL,BH                   ; ATTRIBUTE TO FILL WITH
F53B                     R15:                                    ; CLEAR_LOOP_DOWN
F53B E82900                      CALL    R18                     ; CLEAR A ROW
F53E 81EF5020                    SUB     DI,2000H+80             ; POINT TO NEXT LINE
F542 FECB                        DEC     BL                      ; NUMBER OF LINES TO FILL
F544 75F5                        JNZ     R15                     ; CLEAR_LOOP_DOWN
F546 FC                          CLD                             ; RESET THE DIRECTION FLAG
F547 E97BFC                      JMP     VIDEO_RETURN            ; EVERYTHING DONE
F54A                     R16:                                    ; BLANK_FIELD_DOWN
F54A 8ADE                        MOV     BL,DH                   ; SET BLANK COUNT TO
                                                                 ;  EVERYTHING IN FIELD
F54C EBEB                        JMP     R14                     ; CLEAR THE FIELD
                         GRAPHICS_DOWN   ENDP

                         ;----- ROUTINE TO MOVE ONE ROW OF INFORMATION

F54E                     R17     PROC    NEAR
F54E 8ACA                        MOV     CL,DL                   ; NUMBER OF BYTES IN THE ROW
F550 56                          PUSH    SI
F551 57                          PUSH    DI                      ; SAVE POINTERS
F552 F3                          REP     MOVSB                   ; MOVE THE EVEN FIELD
F553 A4
F554 5F                          POP     DI
F555 5E                          POP     SI
F556 81C60020                    ADD     SI,2000H
F55A 81C70020                    ADD     DI,2000H                ; POINT TO THE ODD FIELD
F55E 56                          PUSH    SI
F55F 57                          PUSH    DI                      ; SAVE THE POINTERS
F560 8ACA                        MOV     CL,DL                   ; COUNT BACK
F562 F3                          REP     MOVSB                   ; MOVE THE ODD FIELD
F563 A4
F564 5F                          POP     DI
F565 5E                          POP     SI                      ; POINTERS BACK
F566 C3                          RET                             ; RETURN TO CALLER
                         R17     ENDP

                         ;----- CLEAR A SINGLE ROW

F567                     R18     PROC    NEAR
F567 8ACA                        MOV     CL,DL                   ; NUMBER OF BYTES IN FIELD
F569 57                          PUSH    DI                      ; SAVE POINTER
F56A F3                          REP     STOSB                   ; STORE THE NEW VALUE
F56B AA
F56C 5F                          POP     DI                      ; POINTER BACK
F56D 81C70020                    ADD     DI,2000H                ; POINT TO ODD FIELD
F571 57                          PUSH    DI
F572 8ACA                        MOV     CL,DL
F574 F3                          REP     STOSB                   ; FILL THE ODD FILELD
F575 AA
F576 5F                          POP     DI
F577 C3                          RET                             ; RETURN TO CALLER
                         R18     ENDP
                         ;--------------------------------------------------------------
                         ; GRAPHICS WRITE                                              :
                         ;       THIS ROUTINE WRITES THE ASCII CHARACTER TO THE        :
                         ;       CURRENT POSITION ON THE SCREEN.                       :
                         ; ENTRY                                                       :
                         ;       AL = CHARACTER TO WRITE                               :
                         ;       BL = COLOR ATTRIBUTE TO BE USED FOR FOREGROUND COLOR  :
                         ;        IF BIT 7 IS SET, THE CHAR IS XOR'D INTO THE REGEN    :
```

```
LOC OBJ              SOURCE

                     ;        BUFFER (0 IS USED FOR THE BACKGROUND COLOR)            :
                     ;       CX = NUMBER OF CHARS TO WRITE                           :
                     ;       DS = DATA SEGMENT                                       :
                     ;       ES = REGEN SEGMENT                                      :
                     ; EXIT                                                          :
                     ;       NOTHING IS RETURNED                                     :
                     ;                                                               :
                     ; GRAPHICS READ                                                 :
                     ;       THIS ROUTINE READS THE ASCII CHARACTER AT THE CURRENT   :
                     ;       CURSOR POSITION ON THE SCREEN BY MATCHING THE DOTS ON   :
                     ;       THE SCREEN TO THE CHARACTER GENERATOR CODE POINTS       :
                     ; ENTRY                                                         :
                     ;       NONE  ( 0 IS ASSUMED AS THE BACKGROUND COLOR            :
                     ; EXIT                                                          :
                     ;       AL = CHARACTER READ AT THAT POSITION (0 RETURNED IF     :
                     ;            NONE FOUND)                                        :
                     ;                                                               :
                     ; FOR BOTH ROUTINES, THE IMAGES USED TO FORM CHARS ARE          :
                     ;  CONTAINED IN ROM FOR THE 1ST 128 CHARS.  TO ACCESS CHARS     :
                     ;  IN THE SECOND HALF, THE USER MUST INITIALIZE THE VECTOR AT   :
                     ;  INTERRUPT 1FH (LOCATION 0007CH) TO POINT TO THE USER         :
                     ;  SUPPLIED TABLE OF GRAPHIC IMAGES (8X8 BOXES).                :
                     ;  FAILURE TO DO SO WILL CAUSE IN STRANGE RESULTS               :
                     ;----------------------------------------------------------------
                             ASSUME  CS:CODE,DS:DATA,ES:DATA
F578                 GRAPHICS_WRITE  PROC    NEAR
F578 B400                    MOV     AH,0                    ; ZERO TO HIGH OF CODE POINT
F57A 50                      PUSH    AX                      ; SAVE CODE POINT VALUE

                     ;----- DETERMINE POSITION IN REGEN BUFFER TO PUT CODE POINTS

F57B E88401                  CALL    S26                     ; FIND LOCATION IN REGEN BUFFER
F57E 8BF8                    MOV     DI,AX                   ; REGEN POINTER IN DI

                     ;----- DETERMINE REGION TO GET CODE POINTS FROM

F580 58                      POP     AX                      ; RECOVER CODE POINT
F581 3C80                    CMP     AL,80H                  ; IS IT IN SECOND HALF
F583 7306                    JAE     S1                      ; YES

                     ;----- IMAGE IS IN FIRST HALF, CONTAINED IN ROM

F585 BE6EFA                  MOV     SI,0FA6EH               ; CRT_CHAR_GEN (OFFSET OF IMAGES)
F588 0E                      PUSH    CS                      ; SAVE SEGMENT ON STACK
F589 EB0F                    JMP     SHORT S2                ; DETERMINE_MODE

                     ;----- IMAGE IS IN SECOND HALF, IN USER RAM

F58B                 S1:                                     ; EXTEND_CHAR
F58B 2C80                    SUB     AL,80H                  ; ZERO ORIGIN FOR SECOND HALF
F58D 1E                      PUSH    DS                      ; SAVE DATA POINTER
F58E 2BF6                    SUB     SI,SI
F590 8EDE                    MOV     DS,SI                   ; ESTABLISH VECTOR ADDRESSING
                             ASSUME  DS:ABS0
F592 C5367C00                LDS     SI,EXT_PTR              ; GET THE OFFSET OF THE TABLE
F596 8CDA                    MOV     DX,DS                   ; GET THE SEGMENT OF THE TABLE
                             ASSUME  DS:DATA
F598 1F                      POP     DS                      ; RECOVER DATA SEGMENT
F599 52                      PUSH    DX                      ; SAVE TABLE SEGMENT ON STACK

                     ;----- DETERMINE GRAPHICS MODE IN OPERATION

F59A                 S2:                                     ; DETERMINE_MODE
F59A D1E0                    SAL     AX,1                    ; MULTIPLY CODE POINT
F59C D1E0                    SAL     AX,1                    ;  VALUE BY 8
F59E D1E0                    SAL     AX,1
F5A0 03F0                    ADD     SI,AX                   ; SI HAS OFFSET OF DESIRED CODES
F5A2 803E490006              CMP     CRT_MODE,6
F5A7 1F                      POP     DS                      ; RECOVER TABLE POINTER SEGMENT
F5A8 722C                    JC      S7                      ; TEST FOR MEDIUM RESOLUTION MODE

                     ;----- HIGH RESOLUTION MODE

F5AA                 S3:                                     ; HIGH_CHAR
F5AA 57                      PUSH    DI                      ; SAVE REGEN POINTER
F5AB 56                      PUSH    SI                      ; SAVE CODE POINTER
F5AC B604                    MOV     DH,4                    ; NUMBER OF TIMES THROUGH LOOP
```

```
LOC OBJ                 LINE    SOURCE

F5AE                            S4:
F5AE AC                                 LODSB                           ; GET BYTE FROM CODE POINTS
F5AF F6C380                             TEST    BL,80H                  ; SHOULD WE USE THE FUNCTION
F5B2 7516                               JNZ     S6                      ;  TO PUT CHAR IN
F5B4 AA                                 STOSB                           ; STORE IN REGEN BUFFER
F5B5 AC                                 LODSB
F5B6                            S5:
F5B6 268885FF1F                         MOV     ES:[DI+2000H-1],AL      ; STORE IN SECOND HALF
F5BB 83C74F                             ADD     DI,79                   ; MOVE TO NEXT ROW IN REGEN
F5BE FECE                               DEC     DH                      ; DONE WITH LOOP
F5C0 75EC                               JNZ     S4
F5C2 5E                                 POP     SI
F5C3 5F                                 POP     DI                      ; RECOVER REGEN POINTER
F5C4 47                                 INC     DI                      ; POINT TO NEXT CHAR POSITION
F5C5 E2E3                               LOOP    S3                      ; MORE CHARS TO WRITE
F5C7 E9FBFB                             JMP     VIDEO_RETURN
F5CA                            S6:
F5CA 263205                             XOR     AL,ES:[DI]              ; EXCLUSIVE OR WITH CURRENT
F5CD AA                                 STOSB                           ; STORE THE CODE POINT
F5CE AC                                 LODSB                           ; AGAIN FOR ODD FIELD
F5CF 263285FF1F                         XOR     AL,ES:[DI+2000H-1]
F5D4 EBE0                               JMP     S5                      ; BACK TO MAINSTREAM

                                ;----- MEDIUM RESOLUTION WRITE

F5D6                            S7:                                     ; MED_RES_WRITE
F5D6 8AD3                               MOV     DL,BL                   ; SAVE HIGH COLOR BIT
F5D8 D1E7                               SAL     DI,1                    ; OFFSET*2 SINCE 2 BYTES/CHAR
F5DA E8D100                             CALL    S19                     ; EXPAND BL TO FULL WORD OF COLOR
F5DD                            S8:                                     ; MED_CHAR
F5DD 57                                 PUSH    DI                      ; SAVE REGEN POINTER
F5DE 56                                 PUSH    SI                      ; SAVE THE CODE POINTER
F5DF B604                               MOV     DH,4                    ; NUMBER OF LOOPS
F5E1                            S9:
F5E1 AC                                 LODSB                           ; GET CODE POINT
F5E2 E8DE00                             CALL    S21                     ; DOUBLE UP ALL THE BITS
F5E5 23C3                               AND     AX,BX                   ; CONVERT THEM TO FOREGROUND
                                                                        ;  COLOR ( 0 BACK )
F5E7 F6C280                             TEST    DL,80H                  ; IS THIS XOR FUNCTION
F5EA 7407                               JZ      S10                     ; NO, STORE IT IN AS IT IS
F5EC 263225                             XOR     AH,ES:[DI]              ; DO FUNCTION WITH HALF
F5EF 26324501                           XOR     AL,ES:[DI+1]            ;  AND WITH OTHER HALF
F5F3                            S10:
F5F3 268825                             MOV     ES:[DI],AH              ; STORE FIRST BYTE
F5F6 26884501                           MOV     ES:[DI+1],AL            ; STORE SECOND BYTE
F5FA AC                                 LODSB                           ; GET CODE POINT
F5FB E8C500                             CALL    S21
F5FE 23C3                               AND     AX,BX                   ; CONVERT TO COLOR
F600 F6C280                             TEST    DL,80H                  ; AGAIN, IS THIS XOR FUNCTION
F603 740A                               JZ      S11                     ; NO, JUST STORE THE VALUES
F605 2632A50020                         XOR     AH,ES:[DI+2000H]        ; FUNCTION WITH FIRST HALF
F60A 2632850120                         XOR     AL,ES:[DI+2001H]        ; AND WITH SECOND HALF
F60F                            S11:
F60F 2688A50020                         MOV     ES:[DI+2000H],AH
F614 2688850120                         MOV     ES:[DI+2000H+1],AL      ; STORE IN SECOND PORTION OF BUFFER
F619 83C750                             ADD     DI,80                   ; POINT TO NEXT LOCATION
F61C FECE                               DEC     DH
F61E 75C1                               JNZ     S9                      ; KEEP GOING
F620 5E                                 POP     SI                      ; RECOVER CODE PONTER
F621 5F                                 POP     DI                      ; RECOVER REGEN POINTER
F622 47                                 INC     DI                      ; POINT TO NEXT CHAR POSITION
F623 47                                 INC     DI
F624 E2B7                               LOOP    S8                      ; MORE TO WRITE
F626 E99CFB                             JMP     VIDEO_RETURN
                                GRAPHICS_WRITE  ENDP
                                ;------------------------
                                ; GRAPHICS READ         :
                                ;------------------------
F629                            GRAPHICS_READ   PROC    NEAR
F629 E8D600                             CALL    S26                     ; CONVERTED TO OFFSET IN REGEN
F62C 8BF0                               MOV     SI,AX                   ; SAVE IN SI
F62E 83EC08                             SUB     SP,8                    ; ALLOCATE SPACE TO SAVE THE
                                                                        ;  READ CODE POINT
F631 8BEC                               MOV     BP,SP                   ; POINTER TO SAVE AREA

                                ;----- DETERMINE GRAPHICS MODES

```

```
LOC OBJ                  SOURCE

F633 803E490006                CMP     CRT_MODE,6
F638 06                        PUSH    ES
F639 1F                        POP     DS                      ; POINT TO REGEN SEGMENT
F63A 721A                      JC      S13                     ; MEDIUM RESOLUTION

                         ;----- HIGH RESOLUTION READ

                         ;----- GET VALUES FROM REGEN BUFFER AND CONVERT TO CODE POINT

F63C B604                      MOV     DH,4                    ; NUMBER OF PASSES
F63E                     S12:
F63E 8A04                      MOV     AL,[SI]                 ; GET FIRST BYTE
F640 884600                    MOV     [BP],AL                 ; SAVE IN STORAGE AREA
F643 45                        INC     BP                      ; NEXT LOCATION
F644 8A840020                  MOV     AL,[SI+2000H]           ; GET LOWER REGION BYTE
F648 884600                    MOV     [BP],AL                 ; ADJUST AND STORE
F64B 45                        INC     BP
F64C 83C650                    ADD     SI,80                   ; POINTER INTO REGEN
F64F FECE                      DEC     DH                      ; LOOP CONTROL
F651 75EB                      JNZ     S12                     ; DO IT SOME MORE
F653 EB1790                    JMP     S15                     ; GO MATCH THE SAVED CODE POINTS

                         ;----- MEDIUM RESOLUTION READ

F656                     S13:                                  ; MED_RES_READ
F656 D1E6                      SAL     SI,1                    ; OFFSET*2 SINCE 2 BYTES/CHAR
F658 B604                      MOV     DH,4                    ; NUMBER OF PASSES
F65A                     S14:
F65A E88800                    CALL    S23                     ; GET PAIR BYTES FROM REGEN
                                                               ;  INTO SINGLE SAVE
F65D 81C60020                  ADD     SI,2000H                ; GO TO LOWER REGION
F661 E88100                    CALL    S23                     ; GET THIS PAIR INTO SAVE
F664 81EEB01F                  SUB     SI,2000H-80             ; ADJUST POINTER BACK INTO UPPER
F668 FECE                      DEC     DH
F66A 75EE                      JNZ     S14                     ; KEEP GOING UNTIL ALL 8 DONE

                         ;----- SAVE AREA HAS CHARACTER IN IT, MATCH IT

F66C                     S15:                                  ; FIND_CHAR
F66C BF6EFA90                  MOV     DI,OFFSET CRT_CHAR_GEN  ; ESTABLISH ADDRESSING
F670 0E                        PUSH    CS
F671 07                        POP     ES                      ; CODE POINTS IN CS
F672 83ED08                    SUB     BP,8                    ; ADJUST POINTER TO BEGINNING
                                                               ;  OF SAVE AREA
F675 8BF5                      MOV     SI,BP
F677 FC                        CLD                             ; ENSURE DIRECTION
F678 B000                      MOV     AL,0                    ; CURRENT CODE POINT BEING MATCHED
F67A                     S16:
F67A 16                        PUSH    SS                      ; ESTABLISH ADDRESSING TO STACK
F67B 1F                        POP     DS                      ; FOR THE STRING COMPARE
F67C BA8000                    MOV     DX,128                  ; NUMBER TO TEST AGAINST
F67F                     S17:
F67F 56                        PUSH    SI                      ; SAVE SAVE AREA POINTER
F680 57                        PUSH    DI                      ; SAVE CODE POINTER
F681 B90800                    MOV     CX,8                    ; NUMBER OF BYTES TO MATCH
F684 F3                        REPE    CMPSB                   ; COMPARE THE 8 BYTES
F685 A6
F686 5F                        POP     DI                      ; RECOVER THE POINTERS
F687 5E                        POP     SI
F688 741E                      JZ      S18                     ; IF ZERO FLAG SET, THEN MATCH OCCURRED
F68A FEC0                      INC     AL                      ; NO MATCH, MOVE ON TO NEXT
F68C 83C708                    ADD     DI,8                    ; NEXT CODE POINT
F68F 4A                        DEC     DX                      ; LOOP CONTROL
F690 75ED                      JNZ     S17                     ; DO ALL OF THEM

                         ;----- CHAR NOT MATCHED, MIGHT BE IN USER SUPPLIED SECOND HALF

F692 3C00                      CMP     AL,0                    ; AL <> 0 IF ONLY 1ST HALF SCANNED
F694 7412                      JE      S18                     ; IF = 0, THEN ALL HAS BEEN SCANNED
F696 2BC0                      SUB     AX,AX
F698 8ED8                      MOV     DS,AX                   ; ESTABLISH ADDRESSING TO VECTOR
                               ASSUME  DS:ABS0
F69A C43E7C00                  LES     DI,EXT_PTR              ; GET POINTER
F69E 8CC0                      MOV     AX,ES                   ; SEE IF THE POINTER REALLY EXISTS
F6A0 0BC7                      OR      AX,DI                   ; IF ALL 0, THEN DOESN'T EXIST
F6A2 7404                      JZ      S18                     ; NO SENSE LOOKING
F6A4 B080                      MOV     AL,128                  ; ORIGIN FOR SECOND HALF
```

Section 5

```
LOC OBJ          LINE    SOURCE

F6A6 EBD2                          JMP     S16                     ; GO BACK AND TRY FOR IT
                                   ASSUME  DS:DATA

                         ;----- CHARACTER IS FOUND ( AL=0 IF NOT FOUND )

F6A8                     S18:
F6A8 83C408                        ADD     SP,8                    ; READJUST THE STACK, THROW AWAY SAVE
F6AB E917FB                        JMP     VIDEO_RETURN            ; ALL DONE
                         GRAPHICS_READ   ENDP
                         ;---------------------------------------------------
                         ; EXPAND_MED_COLOR                                  :
                         ;         THIS ROUTINE EXPANDS THE LOW 2 BITS IN BL TO  :
                         ;         FILL THE ENTIRE BX REGISTER               :
                         ; ENTRY                                             :
                         ;         BL = COLOR TO BE USED ( LOW 2 BITS )      :
                         ; EXIT                                              :
                         ;         BX = COLOR TO BE USED ( 8 REPLICATIONS OF THE  :
                         ;         2 COLOR BITS )                            :
                         ;---------------------------------------------------
F6AE                     S19       PROC    NEAR
F6AE 80E303                        AND     BL,3                    ; ISOLATE THE COLOR BITS
F6B1 8AC3                          MOV     AL,BL                   ; COPY TO AL
F6B3 51                            PUSH    CX                      ; SAVE REGISTER
F6B4 B90300                        MOV     CX,3                    ; NUMBER OF TIMES TO DO THIS
F6B7                     S20:
F6B7 D0E0                          SAL     AL,1
F6B9 D0E0                          SAL     AL,1                    ; LEFT SHIFT BY 2
F6BB 0AD8                          OR      BL,AL                   ; ANOTHER COLOR VERSION INTO BL
F6BD E2F8                          LOOP    S20                     ; FILL ALL OF BL
F6BF 8AFB                          MOV     BH,BL                   ; FILL UPPER PORTION
F6C1 59                            POP     CX                      ; REGISTER BACK
F6C2 C3                            RET                             ; ALL DONE
                         S19       ENDP
                         ;---------------------------------------------------
                         ; EXPAND_BYTE                                       :
                         ;         THIS ROUTINE TAKES THE BYTE IN AL AND DOUBLES  :
                         ;         ALL OF THE BITS, TURNING THE 8 BITS INTO  :
                         ;         16 BITS. THE RESULT IS LEFT IN AX         :
                         ;---------------------------------------------------
F6C3                     S21       PROC    NEAR
F6C3 52                            PUSH    DX                      ; SAVE REGISTERS
F6C4 51                            PUSH    CX
F6C5 53                            PUSH    BX
F6C6 2BD2                          SUB     DX,DX                   ; RESULT REGISTER
F6C8 B90100                        MOV     CX,1                    ; MASK REGISTER
F6CB                     S22:
F6CB 8BD8                          MOV     BX,AX                   ; BASE INTO TEMP
F6CD 23D9                          AND     BX,CX                   ; USE MASK TO EXTRACT A BIT
F6CF 0BD3                          OR      DX,BX                   ; PUT INTO RESULT REGISTER
F6D1 D1E0                          SHL     AX,1
F6D3 D1E1                          SHL     CX,1                    ; SHIFT BASE AND MASK BY 1
F6D5 8BD8                          MOV     BX,AX                   ; BASE TO TEMP
F6D7 23D9                          AND     BX,CX                   ; EXTRACT THE SAME BIT
F6D9 0BD3                          OR      DX,BX                   ; PUT INTO RESULT
F6DB D1E1                          SHL     CX,1                    ; SHIFT ONLY MASK NOW,
                                                                   ;  MOVING TO NEXT BASE
F6DD 73EC                          JNC     S22                     ; USE MASK BIT COMING OUT TO TERMINATE
F6DF 8BC2                          MOV     AX,DX                   ; RESULT TO PARM REGISTER
F6E1 5B                            POP     BX
F6E2 59                            POP     CX                      ; RECOVER REGISTERS
F6E3 5A                            POP     DX
F6E4 C3                            RET                             ; ALL DONE
                         S21       ENDP
                         ;---------------------------------------------------
                         ; MED_READ_BYTE                                     :
                         ;         THIS ROUTINE WILL TAKE 2 BYTES FROM THE REGEN  :
                         ;         BUFFER, COMPARE AGAINST THE CURRENT FOREGROUND  :
                         ;         COLOR, AND PLACE THE CORRESPONDING ON/OFF BIT  :
                         ;         PATTERN INTO THE CURRENT POSITION IN THE SAVE  :
                         ;         AREA                                      :
                         ; ENTRY                                             :
                         ;         SI,DS = POINTER TO REGEN AREA OF INTEREST :
                         ;         BX = EXPANDED FOREGROUND COLOR            :
                         ;         BP = POINTER TO SAVE AREA                 :
                         ; EXIT                                              :
                         ;         BP IS INCREMENT AFTER SAVE                :
                         ;---------------------------------------------------
```

LOC OBJ LINE SOURCE

```
F6E5                S23     PROC    NEAR
F6E5 8A24                   MOV     AH,[SI]                 ; GET FIRST BYTE
F6E7 8A4401                 MOV     AL,[SI+1]               ; GET SECOND BYTE
F6EA B900C0                 MOV     CX,0C000H               ; 2 BIT MASK TO TEST THE ENTRIES
F6ED B200                   MOV     DL,0                    ; RESULT REGISTER
F6EF                S24:
F6EF 85C1                   TEST    AX,CX                   ; IS THIS SECTION BACKGROUND?
F6F1 F8                     CLC                             ; CLEAR CARRY IN HOPES THAT IT IS
F6F2 7401                   JZ      S25                     ; IF ZERO, IT IS BACKGROUND
F6F4 F9                     STC                             ; WASN'T, SO SET CARRY
F6F5 D0D2           S25:    RCL     DL,1                    ; MOVE THAT BIT INTO THE RESULT
F6F7 D1E9                   SHR     CX,1
F6F9 D1E9                   SHR     CX,1                    ; MOVE THE MASK TO THE RIGHT BY 2 BITS
F6FB 73F2                   JNC     S24                     ; DO IT AGAIN IF MASK DIDN'T FALL OUT
F6FD 885600                 MOV     [BP],DL                 ; STORE RESULT IN SAVE AREA
F700 45                     INC     BP                      ; ADJUST POINTER
F701 C3                     RET                             ; ALL DONE
                    S23     ENDP
                    ;---------------------------------------------
                    ; V4_POSITION                                 :
                    ;       THIS ROUTINE TAKES THE CURSOR POSITION :
                    ;       CONTAINED IN THE MEMORY LOCATION, AND  :
                    ;       CONVERTS IT INTO AN OFFSET INTO THE    :
                    ;       REGEN BUFFER, ASSUMING ONE BYTE/CHAR.  :
                    ;       FOR MEDIUM RESOLUTION GRAPHICS,        :
                    ;       THE NUMBER MUST BE DOUBLED.            :
                    ; ENTRY                                       :
                    ;       NO REGISTERS, MEMORY LOCATION          :
                    ;       CURSOR_POSN IS USED                    :
                    ; EXIT                                        :
                    ;       AX CONTAINS OFFSET INTO REGEN BUFFER   :
                    ;---------------------------------------------
F702                S26     PROC    NEAR
F702 A15000                 MOV     AX,CURSOR_POSN          ; GET CURRENT CURSOR
F705                GRAPH_POSN      LABEL   NEAR
F705 53                     PUSH    BX                      ; SAVE REGISTER
F706 8BD8                   MOV     BX,AX                   ; SAVE A COPY OF CURRENT CURSOR
F708 8AC4                   MOV     AL,AH                   ; GET ROWS TO AL
F70A F6264A00               MUL     BYTE PTR CRT_COLS       ; MULTIPLY BY BYTES/COLUMN
F70E D1E0                   SHL     AX,1                    ; MULTIPLY * 4 SINCE 4 ROWS/BYTE
F710 D1E0                   SHL     AX,1
F712 2AFF                   SUB     BH,BH                   ; ISOLATE COLUMN VALUE
F714 03C3                   ADD     AX,BX                   ; DETERMINE OFFSET
F716 5B                     POP     BX                      ; RECOVER POINTER
F717 C3                     RET                             ; ALL DONE
                    S26     ENDP
                    ;---------------------------------------------------------------------
                    ; WRITE_TTY                                                           :
                    ;       THIS INTERFACE PROVIDES A TELETYPE LIKE INTERFACE TO THE VIDEO :
                    ;       CARD. THE INPUT CHARACTER IS WRITTEN TO THE CURRENT CURSOR     :
                    ;       POSITION, AND THE CURSOR IS MOVED TO THE NEXT POSITION. IF THE :
                    ;       CURSOR LEAVES THE LAST COLUMN OF THE FIELD, THE COLUMN IS SET  :
                    ;       TO ZERO, AND THE ROW VALUE IS INCREMENTED. IF THE ROW VALUE    :
                    ;       LEAVES THE FIELD, THE CURSOR IS PLACED ON THE LAST ROW, FIRST  :
                    ;       COLUMN, AND THE ENTIRE SCREEN IS SCROLLED UP ONE LINE. WHEN    :
                    ;       THE SCREEN IS SCROLLED UP, THE ATTRIBUTE FOR FILLING THE NEWLY :
                    ;       BLANKED LINE IS READ FROM THE CURSOR POSITION ON THE PREVIOUS  :
                    ;       LINE BEFORE THE SCROLL, IN CHARACTER MODE. IN GRAPHICS MODE,   :
                    ;       THE 0 COLOR IS USED.                                           :
                    ; ENTRY                                                               :
                    ;       (AH) = CURRENT CRT MODE                                        :
                    ;       (AL) = CHARACTER TO BE WRITTEN                                 :
                    ;        NOTE THAT BACK SPACE, CAR RET, BELL AND LINE FEED ARE HANDLED :
                    ;        AS COMMANDS RATHER THAN AS DISPLAYABLE GRAPHICS               :
                    ;       (BL) = FOREGROUND COLOR FOR CHAR WRITE IF CURRENTLY IN A       :
                    ;        GRAPHICS MODE                                                 :
                    ; EXIT                                                                :
                    ;       ALL REGISTERS SAVED                                            :
                    ;---------------------------------------------------------------------
                            ASSUME  CS:CODE,DS:DATA
F718                WRITE_TTY       PROC    NEAR
F718 50                     PUSH    AX                      ; SAVE REGISTERS
F719 50                     PUSH    AX                      ; SAVE CHAR TO WRITE
F71A B403                   MOV     AH,3
F71C 8A3E6200               MOV     BH,ACTIVE_PAGE          ; GET THE CURRENT ACTIVE PAGE
F720 CD10                   INT     10H                     ; READ THE CURRENT CURSOR POSITION
F722 58                     POP     AX                      ; RECOVER CHAR
```

```
LOC OBJ              SOURCE

                     ;----- DX NOW HAS THE CURRENT CURSOR POSITION

F723 3C08                    CMP     AL,8                        ; IS IT A BACKSPACE
F725 7452                    JE      U8                          ; BACK_SPACE
F727 3C0D                    CMP     AL,0DH                      ; IS IT CARRIAGE RETURN
F729 7457                    JE      U9                          ; CAR_RET
F72B 3C0A                    CMP     AL,0AH                      ; IS IT A LINE FEED
F72D 7457                    JE      U10                         ; LINE_FEED
F72F 3C07                    CMP     AL,07H                      ; IS IT A BELL
F731 745A                    JE      U11                         ; BELL

                     ;----- WRITE THE CHAR TO THE SCREEN

F733 B40A                    MOV     AH,10                       ; WRITE CHAR ONLY
F735 B90100                  MOV     CX,1                        ; ONLY ONE CHAR
F738 CD10                    INT     10H                         ; WRITE THE CHAR

                     ;----- POSITION THE CURSOR FOR NEXT CHAR

F73A FEC2                    INC     DL
F73C 3A164A00                CMP     DL,BYTE PTR CRT_COLS        ; TEST FOR COLUMN OVERFLOW
F740 7533                    JNZ     U7                          ; SET_CURSOR
F742 B200                    MOV     DL,0                        ; COLUMN FOR CURSOR
F744 80FE18                  CMP     DH,24
F747 752A                    JNZ     U6                          ; SET_CURSOR_INC

                     ;----- SCROLL REQUIRED

F749                 U1:
F749 B402                    MOV     AH,2
F74B CD10                    INT     10H                         ; SET THE CURSOR

                     ;----- DETERMINE VALUE TO FILL WITH DURING SCROLL

F74D A04900                  MOV     AL,CRT_MODE                 ; GET THE CURRENT MODE
F750 3C04                    CMP     AL,4
F752 7206                    JC      U2                          ; READ-CURSOR
F754 3C07                    CMP     AL,7
F756 B700                    MOV     BH,0                        ; FILL WITH BACKGROUND
F758 7506                    JNE     U3                          ; SCROLL-UP
F75A                 U2:                                         ; READ-CURSOR
F75A B408                    MOV     AH,8
F75C CD10                    INT     10H                         ; READ CHAR/ATTR AT CURRENT CURSOR
F75E 8AFC                    MOV     BH,AH                       ; STORE IN BH
F760                 U3:                                         ; SCROLL-UP
F760 B80106                  MOV     AX,601H                     ; SCROLL ONE LINE
F763 2BC9                    SUB     CX,CX                       ; UPPER LEFT CORNER
F765 B618                    MOV     DH,24                       ; LOWER RIGHT ROW
F767 8A164A00                MOV     DL,BYTE PTR CRT_COLS        ; LOWER RIGHT COLUMN
F76B FECA                    DEC     DL
F76D                 U4:                                         ; VIDEO-CALL-RETURN
F76D CD10                    INT     10H                         ; SCROLL UP THE SCREEN
F76F                 U5:                                         ; TTY-RETURN
F76F 58                      POP     AX                          ; RESTORE THE CHARACTER
F770 E952FA                  JMP     VIDEO_RETURN                ; RETURN TO CALLER
F773                 U6:                                         ; SET-CURSOR-INC
F773 FEC6                    INC     DH                          ; NEXT ROW
F775                 U7:                                         ; SET-CURSOR
F775 B402                    MOV     AH,2
F777 EBF4                    JMP     U4                          ; ESTABLISH THE NEW CURSOR

                     ;----- BACK SPACE FOUND

F779                 U8:
F779 80FA00                  CMP     DL,0                        ; ALREADY AT END OF LINE
F77C 74F7                    JE      U7                          ; SET_CURSOR
F77E FECA                    DEC     DL                          ; NO -- JUST MOVE IT BACK
F780 EBF3                    JMP     U7                          ; SET_CURSOR

                     ;----- CARRIAGE RETURN FOUND

F782                 U9:
F782 B200                    MOV     DL,0                        ; MOVE TO FIRST COLUMN
F784 EBEF                    JMP     U7                          ; SET_CURSOR
```

```
LOC OBJ                 LINE    SOURCE

                                ;----- LINE FEED FOUND
F786                            U10:
F786 80FE18                             CMP     DH,24                   ; BOTTOM OF SCREEN
F789 75E8                               JNE     U6                      ; YES, SCROLL THE SCREEN
F78B EBBC                               JMP     U1                      ; NO, JUST SET THE CURSOR

                                ;----- BELL FOUND
F78D                            U11:
F78D B302                               MOV     BL,2                    ; SET UP COUNT FOR BEEP
F78F E871EE                             CALL    BEEP                    ; SOUND THE POD BELL
F792 EBDB                               JMP     U5                      ; TTY_RETURN
                                WRITE_TTY       ENDP
                                ;--------------------------------------------------------------
                                ; LIGHT PEN                                                    :
                                ;       THIS ROUTINE TESTS THE LIGHT PEN SWITCH AND THE LIGHT  :
                                ;       PEN TRIGGER. IF BOTH ARE SET, THE LOCATION OF THE LIGHT :
                                ;       PEN IS DETERMINED. OTHERWISE, A RETURN WITH NO         :
                                ;       INFORMATION IS MADE.                                   :
                                ; ON EXIT                                                      :
                                ;       (AH) = 0 IF NO LIGHT PEN INFORMATION IS AVAILABLE      :
                                ;               BX,CX,DX ARE DESTROYED                         :
                                ;       (AH) = 1 IF LIGHT PEN IS AVAILABLE                     :
                                ;               (DH,DL) = ROW,COLUMN OF CURRENT LIGHT PEN      :
                                ;                         POSITION                             :
                                ;               (CH) = RASTER POSITION                         :
                                ;               (BX) = BEST GUESS AT PIXEL HORIZONTAL POSITION :
                                ;--------------------------------------------------------------
                                        ASSUME  CS:CODE,DS:DATA
                                ;----- SUBTRACT_TABLE
F794                            V1      LABEL   BYTE
F794 03                                 DB      3,3,5,5,3,3,3,4 ;
F795 03
F796 05
F797 05
F798 03
F799 03
F79A 03
F79B 04
F79C                            READ_LPEN       PROC    NEAR

                                ;----- WAIT FOR LIGHT PEN TO BE DEPRESSED
F79C B400                               MOV     AH,0                    ; SET NO LIGHT PEN RETURN CODE
F79E 8B166300                           MOV     DX,ADDR_6845            ; GET BASE ADDRESS OF 6845
F7A2 83C206                             ADD     DX,6                    ; POINT TO STATUS REGISTER
F7A5 EC                                 IN      AL,DX                   ; GET STATUS REGISTER
F7A6 A804                               TEST    AL,4                    ; TEST LIGHT PEN SWITCH
F7A8 757E                               JNZ     V6                      ; NOT SET, RETURN

                                ;----- NOW TEST FOR LIGHT PEN TRIGGER
F7AA A802                               TEST    AL,2                    ; TEST LIGHT PEN TRIGGER
F7AC 7503                               JNZ     V7A                     ; RETURN WITHOUT RESETTING TRIGGER
F7AE E98100                             JMP     V7

                                ;----- TRIGGER HAS BEEN SET, READ THE VALUE IN
F7B1                            V7A:
F7B1 B410                               MOV     AH,16                   ; LIGHT PEN REGISTERS ON 6845

                                ;----- INPUT REGS POINTED TO BY AH, AND CONVERT TO ROW COLUMN IN DX
F7B3 8B166300                           MOV     DX,ADDR_6845            ; ADDRESS REGISTER FOR 6845
F7B7 8AC4                               MOV     AL,AH                   ; REGISTER TO READ
F7B9 EE                                 OUT     DX,AL                   ; SET IT UP
F7BA 42                                 INC     DX                      ; DATA REGISTER
F7BB EC                                 IN      AL,DX                   ; GET THE VALUE
F7BC 8AE8                               MOV     CH,AL                   ; SAVE IN CX
F7BE 4A                                 DEC     DX                      ; ADDRESS REGISTER
F7BF FEC4                               INC     AH
F7C1 8AC4                               MOV     AL,AH                   ; SECOND DATA REGISTER
F7C3 EE                                 OUT     DX,AL
F7C4 42                                 INC     DX                      ; POINT TO DATA REGISTER
F7C5 EC                                 IN      AL,DX                   ; GET SECOND DATA VALUE
F7C6 8AE5                               MOV     AH,CH                   ; AX HAS INPUT VALUE
```

```
LOC OBJ               SOURCE

                      ;----- AX HAS THE VALUE READ IN FROM THE 6845

F7C8 8A1E4900                 MOV     BL,CRT_MODE
F7CC 2AFF                     SUB     BH,BH                   ; MODE VALUE TO BX
F7CE 2E8A9F94F7               MOV     BL,CS:V1[BX]            ; DETERMINE AMOUNT TO SUBTRACT
F7D3 2BC3                     SUB     AX,BX                   ; TAKE IT AWAY
F7D5 8B1E4E00                 MOV     BX,CRT_START
F7D9 D1EB                     SHR     BX,1
F7DB 2BC3                     SUB     AX,BX
F7DD 7902                     JNS     V2                      ; IF POSITIVE, DETERMINE MODE
F7DF 2BC0                     SUB     AX,AX                   ; <0 PLAYS AS 0

                      ;----- DETERMINE MODE OF OPERATION

F7E1                  V2:                                     ; DETERMINE_MODE
F7E1 B103                     MOV     CL,3                    ; SET *8 SHIFT COUNT
F7E3 803E490004               CMP     CRT_MODE,4              ; DETERMINE IF GRAPHICS OR ALPHA
F7E8 722A                     JB      V4                      ; ALPHA_PEN
F7EA 803E490007               CMP     CRT_MODE,7
F7EF 7423                     JE      V4                      ; ALPHA_PEN

                      ;----- GRAPHICS MODE

F7F1 B228                     MOV     DL,40                   ; DIVISOR FOR GRAPHICS
F7F3 F6F2                     DIV     DL                      ; DETERMINE ROW(AL) AND COLUMN(AH)
                                                              ;  AL RANGE 0-99, AH RANGE 0-39

                      ;----- DETERMINE GRAPHIC ROW POSITION

F7F5 8AE8                     MOV     CH,AL                   ; SAVE ROW VALUE IN CH
F7F7 02ED                     ADD     CH,CH                   ; *2 FOR EVEN/ODD FIELD
F7F9 8ADC                     MOV     BL,AH                   ; COLUMN VALUE TO BX
F7FB 2AFF                     SUB     BH,BH                   ; MULTIPLY BY 8 FOR MEDIUM RES
F7FD 803E490006               CMP     CRT_MODE,6              ; DETERMINE MEDIUM OR HIGH RES
F802 7504                     JNE     V3                      ; NOT_HIGH_RES
F804 B104                     MOV     CL,4                    ; SHIFT VALUE FOR HIGH RES
F806 D0E4                     SAL     AH,1                    ; COLUMN VALUE TIMES 2 FOR HIGH RES
F808                  V3:                                     ; NOT_HIGH_RES
F808 D3E3                     SHL     BX,CL                   ; MULTIPLY *16 FOR HIGH RES

                      ;----- DETERMINE ALPHA CHAR POSITION

F80A 8AD4                     MOV     DL,AH                   ; COLUMN VALUE FOR RETURN
F80C 8AF0                     MOV     DH,AL                   ; ROW VALUE
F80E D0EE                     SHR     DH,1                    ; DIVIDE BY 4
F810 D0EE                     SHR     DH,1                    ;  FOR VALUE IN 0-24 RANGE
F812 EB12                     JMP     SHORT V5                ; LIGHT_PEN_RETURN_SET

                      ;----- ALPHA MODE ON LIGHT PEN

F814                  V4:                                     ; ALPHA_PEN
F814 F6364A00                 DIV     BYTE PTR CRT_COLS       ; DETERMINE ROW,COLUMN VALUE
F818 8AF0                     MOV     DH,AL                   ; ROWS TO DH
F81A 8AD4                     MOV     DL,AH                   ; COLS TO DL
F81C D2E0                     SAL     AL,CL                   ; MULTIPLY ROWS * 8
F81E 8AE8                     MOV     CH,AL                   ; GET RASTER VALUE TO RETURN REG
F820 8ADC                     MOV     BL,AH                   ; COLUMN VALUE
F822 32FF                     XOR     BH,BH                   ;  TO BX
F824 D3E3                     SAL     BX,CL
F826                  V5:                                     ; LIGHT_PEN_RETURN_SET
F826 B401                     MOV     AH,1                    ; INDICATE EVERTHING SET
F828                  V6:                                     ; LIGHT_PEN_RETURN
F828 52                       PUSH    DX                      ; SAVE RETURN VALUE (IN CASE)
F829 8B166300                 MOV     DX,ADDR_6845            ; GET BASE ADDRESS
F82D 83C207                   ADD     DX,7                    ; POINT TO RESET PARM
F830 EE                       OUT     DX,AL                   ; ADDRESS, NOT DATA, IS IMPORTANT
F831 5A                       POP     DX                      ; RECOVER VALUE
F832                  V7:                                     ; RETURN_NO_RESET
F832 5F                       POP     DI
F833 5E                       POP     SI
F834 1F                       POP     DS                      ; DISCARD SAVED BX,CX,DX
F835 1F                       POP     DS
F836 1F                       POP     DS

F837 1F                       POP     DS
F838 07                       POP     ES
```

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LOC OBJ          LINE    SOURCE

F839 CF                          IRET
                         READ_LPEN       ENDP

                         ;--- INT 12 ------------------------------------------------------------
                         ; MEMORY_SIZE_DET                                                      :
                         ;       THIS ROUTINE DETERMINES THE AMOUNT OF MEMORY IN THE SYSTEM     :
                         ;       AS REPRESENTED BY THE SWITCHES ON THE PLANAR.  NOTE THAT THE   :
                         ;       SYSTEM MAY NOT BE ABLE TO USE I/O MEMORY UNLESS THERE IS A FULL :
                         ;       COMPLEMENT OF 64K BYTES ON THE PLANAR.                         :
                         ; INPUT                                                                :
                         ;       NO REGISTERS                                                   :
                         ;       THE MEMORY_SIZE VARIABLE IS SET DURING POWER ON DIAGNOSTICS    :
                         ;        ACCORDING TO THE FOLLOWING HARDWARE ASSUMPTIONS:              :
                         ;       PORT 60 BITS 3,2 = 00 - 16K BASE RAM                           :
                         ;                          01 - 32K BASE RAM                           :
                         ;                          10 - 48K BASE RAM                           :
                         ;                          11 - 64K BASE RAM                           :
                         ;       PORT 62 BITS 3-0 INDICATE AMOUNT OF I/O RAM IN 32K INCREMENTS  :
                         ;               E.G., 0000 - NO RAM IN I/O CHANNEL                     :
                         ;                     0010 - 64K RAM IN I/O CHANNEL, ETC.              :
                         ; OUTPUT                                                               :
                         ;       (AX) = NUMBER OF CONTIGUOUS 1K BLOCKS OF MEMORY                :
                         ;-----------------------------------------------------------------------
                                 ASSUME  CS:CODE,DS:DATA
F841                             ORG     0F841H
F841                     MEMORY_SIZE_DET PROC    FAR
F841 FB                          STI                             ; INTERRUPTS BACK ON
F842 1E                          PUSH    DS                      ; SAVE SEGMENT
F843 E8F806                      CALL    DDS
F846 A11300                      MOV     AX,MEMORY_SIZE          ; GET VALUE
F849 1F                          POP     DS                      ; RECOVER SEGMENT
F84A CF                          IRET                            ; RETURN TO CALLER
                         MEMORY_SIZE_DET  ENDP

                         ;--- INT 11 ----------------------------------------------------
                         ; EQUIPMENT DETERMINATION                                      :
                         ;       THIS ROUTINE ATTEMPTS TO DETERMINE WHAT OPTIONAL       :
                         ;       DEVICES ARE ATTACHED TO THE SYSTEM.                    :
                         ; INPUT                                                        :
                         ;       NO REGISTERS                                           :
                         ;       THE EQUIP_FLAG VARIABLE IS SET DURING THE POWER ON     :
                         ;       DIAGNOSTICS USING THE FOLLOWING HARDWARE ASSUMPTIONS:  :
                         ;       PORT 60  = LOW ORDER BYTE OF EQUPMENT                  :
                         ;       PORT 3FA = INTERRUPT ID REGISTER OF 8250               :
                         ;               BITS 7-3 ARE ALWAYS 0                          :
                         ;       PORT 378 = OUTPUT PORT OF PRINTER -- 8255 PORT THAT    :
                         ;               CAN BE READ AS WELL AS WRITTEN                 :
                         ; OUTPUT                                                       :
                         ;       (AX) IS SET, BIT SIGNIFICANT, TO INDICATE ATTACHED I/O :
                         ;       BIT 15,14 = NUMBER OF PRINTERS ATTACHED                :
                         ;       BIT 13 NOT USED                                        :
                         ;       BIT 12 = GAME I/O ATTACHED                             :
                         ;       BIT 11,10,9 = NUMBER OF RS232 CARDS ATTACHED           :
                         ;       BIT 8 UNUSED                                           :
                         ;       BIT 7,6 = NUMBER OF DISKETTE DRIVES                    :
                         ;               00=1, 01=2, 10=3, 11=4 ONLY IF BIT 0 = 1       :
                         ;       BIT 5,4 = INITIAL VIDEO MODE                           :
                         ;                       00 - UNUSED                            :
                         ;                       01 - 40X25 BW USING COLOR CARD         :
                         ;                       10 - 80X25 BW USING COLOR CARD         :
                         ;                       11 - 80X25 BW USING BW CARD            :
                         ;       BIT 3,2 = PLANAR RAM SIZE (00=16K,01=32K,10=48K,11=64K) :
                         ;       BIT 1 NOT USED                                         :
                         ;       BIT 0 = IPL FROM DISKETTE -- THIS BIT INDICATES THAT   :
                         ;               THERE ARE DISKETTE DRIVES ON THE SYSTEM        :
                         ;                                                              :
                         ;       NO OTHER REGISTERS AFFECTED                            :
                         ;--------------------------------------------------------------
                                 ASSUME  CS:CODE,DS:DATA
F84D                             ORG     0F84DH
F84D                     EQUIPMENT       PROC    FAR
F84D FB                          STI                             ; INTERRUPTS BACK ON
F84E 1E                          PUSH    DS                      ; SAVE SEGMENT REGISTER
F84F E8EC06                      CALL    DDS
F852 A11000                      MOV     AX,EQUIP_FLAG           ; GET THE CURRENT SETTINGS
F855 1F                          POP     DS                      ; RECOVER SEGMENT
F856 CF                          IRET                            ; RETURN TO CALLER
```

```
LOC OBJ                 SOURCE

                        EQUIPMENT       ENDP

                        ;--- INT 15 ----------------------------------------------------
                        ; CASSETTE I/O                                                  :
                        ;       (AH) = 0  TURN CASSETTE MOTOR ON                        :
                        ;       (AH) = 1  TURN CASSETTE MOTOR OFF                       :
                        ;       (AH) = 2  READ 1 OR MORE 256 BYTE BLOCKS FROM CASSETTE  :
                        ;               (ES,BX) = POINTER TO DATA BUFFER                :
                        ;               (CX) = COUNT OF BYTES TO READ                   :
                        ; ON EXIT                                                       :
                        ;       (ES,BX) = POINTER TO LAST BYTE READ + 1                 :
                        ;       (DX) = COUNT OF BYTES ACTUALLY READ                     :
                        ;       (CY) = 0 IF NO ERROR OCCURRED                           :
                        ;            = 1 IF ERROR OCCURRED                              :
                        ;       (AH) = ERROR RETURN IF (CY)= 1                          :
                        ;               = 01 IF CRC ERROR WAS DETECTED                  :
                        ;               = 02 IF DATA TRANSITIONS ARE LOST               :
                        ;               = 04 IF NO DATA WAS FOUND                       :
                        ;       (AH) = 3 WRITE 1 OR MORE 256 BYTE BLOCKS TO CASSETTE    :
                        ;               (ES,BX) = POINTER TO DATA BUFFER                :
                        ;               (CX) = COUNT OF BYTES TO WRITE                  :
                        ; ON EXIT                                                       :
                        ;       (EX,BX) = POINTER TO LAST BYTE WRITTEN + 1              :
                        ;       (CX) = 0                                                :
                        ;       (AH) = ANY OTHER THAN ABOVE VALUES CAUSES (CY)= 1       :
                        ;               AND (AH)= 80 TO BE RETURNED (INVALID COMMAND).  :
                        ;---------------------------------------------------------------
                                ASSUME  DS:DATA,ES:NOTHING,SS:NOTHING,CS:CODE
F859                            ORG     0F859H
F859                    CASSETTE_IO     PROC    FAR
F859 FB                         STI                             ; INTERRUPTS BACK ON
F85A 1E                         PUSH    DS                      ; ESTABLISH ADDRESSING TO DATA
F85B E8E006                     CALL    DDS
F85E 802671007F                 AND     BIOS_BREAK, 7FH         ; MAKE SURE BREAK FLAG IS OFF
F863 E80400                     CALL    W1                      ; CASSETTE_IO_CONT
F866 1F                         POP     DS
F867 CA0200                     RET     2                       ; INTERRUPT RETURN
                        CASSETTE_IO     ENDP
F86A                    W1      PROC    NEAR
                        ;------------------------------------------------------
                        ; PURPOSE:                                             :
                        ;  TO CALL APPROPRIATE ROUTINE DEPENDING ON REG AH     :
                        ;                                                      :
                        ;  AH           ROUTINE                                :
                        ;------------------------------------------------------
                        ;  0            MOTOR ON                               :
                        ;  1            MOTOR OFF                              :
                        ;  2            READ CASSETTE BLOCK                    :
                        ;  3            WRITE CASSETTE BLOCK                   :
                        ;------------------------------------------------------
F86A 0AE4                       OR      AH,AH                   ; TURN ON MOTOR?
F86C 7413                       JZ      MOTOR_ON                ; YES, DO IT
F86E FECC                       DEC     AH                      ; TURN OFF MOTOR?
F870 7418                       JZ      MOTOR_OFF               ; YES, DO IT
F872 FECC                       DEC     AH                      ; READ CASSETTE BLOCK?
F874 741A                       JZ      READ_BLOCK              ; YES, DO IT
F876 FECC                       DEC     AH                      ; WRITE CASSETTE BLOCK?
F878 7503                       JNZ     W2                      ;  NOT_DEFINED
F87A E92401                     JMP     WRITE_BLOCK             ; YES, DO IT
F87D                    W2:                                     ; COMMAND NOT DEFINED
F87D B480                       MOV     AH,080H                 ; ERROR, UNDEFINED OPERATION
F87F F9                         STC                             ; ERROR FLAG
F880 C3                         RET
                        W1      ENDP
F881                    MOTOR_ON        PROC    NEAR
                        ;----------------------------------------
                        ; PURPOSE:                               :
                        ;       TO TURN ON CASSETTE MOTOR        :
                        ;----------------------------------------
F881 E461                       IN      AL,PORT_B               ; READ CASSETTE OUTPUT
F883 24F7                       AND     AL,NOT 08H              ; CLEAR BIT TO TURN ON MOTOR
F885                    W3:
F885 E661                       OUT     PORT_B,AL               ; WRITE IT OUT
F887 2AE4                       SUB     AH,AH                   ; CLEAR AH
F889 C3                         RET
                        MOTOR_ON        ENDP
F88A                    MOTOR_OFF       PROC    NEAR
```

```
LOC OBJ               SOURCE

                      ;---------------------------------------
                      ; PURPOSE:                              :
                      ;       TO TURN CASSETTE MOTOR OFF      :
                      ;---------------------------------------
F88A E461                     IN      AL,PORT_B               ; READ CASSETTE OUTPUT
F88C 0C08                     OR      AL,08H                  ; SET BIT TO TURN OFF
F88E EBF5                     JMP     W3                      ; WRITE IT, CLEAR ERROR, RETURN
                      MOTOR_OFF       ENDP
F890                  READ_BLOCK      PROC    NEAR
                      ;------------------------------------------------------------
                      ; PURPOSE:                                                   :
                      ;       TO READ 1 OR MORE 256 BYTE BLOCKS FROM CASSETTE      :
                      ;                                                            :
                      ; ON ENTRY:                                                  :
                      ;       ES IS SEGMENT FOR MEMORY BUFFER (FOR COMPACT CODE)   :
                      ;       BX POINTS TO START OF MEMORY BUFFER                  :
                      ;       CX CONTAINS NUMBER OF BYTES TO READ                  :
                      ; ON EXIT:                                                   :
                      ;       BX POINTS 1 BYTE PAST LAST BYTE PUT IN MEM           :
                      ;       CX CONTAINS DECREMENTED BYTE COUNT                   :
                      ;       DX CONTAINS NUMBER OF BYTES ACTUALLY READ            :
                      ;                                                            :
                      ;       CARRY FLAG IS CLEAR IF NO ERROR DETECTED             :
                      ;       CARRY FLAG IS SET IF CRC ERROR DETECTED              :
                      ;------------------------------------------------------------
F890 53                       PUSH    BX                      ; SAVE BX
F891 51                       PUSH    CX                      ; SAVE CX
F892 56                       PUSH    SI                      ; SAVE SI
F893 BE0700                   MOV     SI, 7                   ; SET UP RETRY COUNT FOR LEADER
F896 E8BF01                   CALL    BEGIN_OP                ; BEGIN BY STARTING MOTOR
F899                  W4:                                     ; SEARCH FOR LEADER
F899 E462                     IN      AL,PORT_C               ; GET INTIAL VALUE
F89B 2410                     AND     AL,010H                 ; MASK OFF EXTRANEOUS BITS
F89D A26B00                   MOV     LAST_VAL,AL             ; SAVE IN LOC LAST_VAL
F8A0 BA7A3F                   MOV     DX,16250                ; # OF TRANSITIONS TO LOOK FOR
F8A3                  W5:                                     ; WAIT_FOR_EDGE
F8A3 F606710080               TEST    BIOS_BREAK, 80H         ; CHECK FOR BREAK KEY
F8A8 7503                     JNZ     W6A                     ; JUMP IF NO BREAK KEY
                                                              ; JUMP IF BREAK KEY HIT
F8AA                  W6:
F8AA 4A                       DEC     DX
F8AB 7503                     JNZ     W7                      ; JUMP IF BEGINNING OF LEADER
F8AD                  W6A:
F8AD E98400                   JMP     W17                     ; JUMP IF NO LEADER FOUND
F8B0                  W7:
F8B0 E8C600                   CALL    READ_HALF_BIT           ; IGNORE FIRST EDGE
F8B3 E3EE                     JCXZ    W5                      ; JUMP IF NO EDGE DETECTED
F8B5 BA7803                   MOV     DX,0378H                ; CHECK FOR HALF BITS
F8B8 B90002                   MOV     CX,200H                 ; MUST HAVE AT LEAST THIS MANY ONE SIZE
                                                              ; PULSES BEFORE CHCKNG FOR SYNC BIT (0)
F8BB E421                     IN      AL, 021H                ; INTERRUPT MASK REGISTER
F8BD 0C01                     OR      AL,1                    ; DISABLE TIMER INTERRUPTS
F8BF E621                     OUT     021H, AL
F8C1                  W8:                                     ; SEARCH-LDR
F8C1 F606710080               TEST    BIOS_BREAK, 80H         ; CHECK FOR BREAK KEY
F8C6 756C                     JNZ     W17                     ; JUMP IF BREAK KEY HIT
F8C8 51                       PUSH    CX                      ; SAVE REG CX
F8C9 E8AD00                   CALL    READ_HALF_BIT           ; GET PULSE WIDTH
F8CC 0BC9                     OR      CX, CX                  ; CHECK FOR TRANSITION
F8CE 59                       POP     CX                      ; RESTORE ONE BIT COUNTER
F8CF 74C8                     JZ      W4                      ; JUMP IF NO TRANSITION
F8D1 3BD3                     CMP     DX,BX                   ; CHECK PULSE WIDTH
F8D3 E304                     JCXZ    W9                      ; IF CX=0 THEN WE CAN LOOK
                                                              ; FOR SYNC BIT (0)
F8D5 73C2                     JNC     W4                      ; JUMP IF ZERO BIT (NOT GOOD LEADER)
F8D7 E2E8                     LOOP    W8                      ; DEC CX AND READ ANOTHER HALF ONE BIT
F8D9                  W9:                                     ; FIND-SYNC
F8D9 72E6                     JC      W8                      ; JUMP IF ONE BIT (STILL LEADER)

                      ;----- A SYNCH BIT HAS BEEN FOUND.  READ SYN CHARACTER:

F8DB E89B00                   CALL    READ_HALF_BIT           ; SKIP OTHER HALF OF SYNC BIT (0)
F8DE E86A00                   CALL    READ_BYTE               ; READ SYN BYTE
F8E1 3C16                     CMP     AL, 16H                 ; SYNCHRONIZATION CHARACTER
F8E3 7549                     JNE     W16                     ; JUMP IF BAD LEADER FOUND.

                      ;----- GOOD CRC SO READ DATA BLOCK(S)
```

Section 5

```
LOC OBJ                 LINE    SOURCE

F8E5 5E                                 POP     SI                      ; RESTORE REGS
F8E6 59                                 POP     CX
F8E7 5B                                 POP     BX
                                ;--------------------------------------------------------------
                                ; READ 1 OR MORE 256 BYTE BLOCKS FROM CASSETTE              :
                                ;                                                           :
                                ; ON ENTRY:                                                 :
                                ;       ES IS SEGMENT FOR MEMORY BUFFER (FOR COMPACT CODE)  :
                                ;       BX POINTS TO START OF MEMORY BUFFER                 :
                                ;       CX CONTAINS NUMBER OF BYTES TO READ                 :
                                ; ON EXIT:                                                  :
                                ;       BX POINTS 1 BYTE PAST LAST BYTE PUT IN MEM          :
                                ;       CX CONTAINS DECREMENTED BYTE COUNT                  :
                                ;       DX CONTAINS NUMBER OF BYTES ACTUALLY READ           :
                                ;--------------------------------------------------------------
F8E8 51                                 PUSH    CX                      ; SAVE BYTE COUNT
F8E9                            W10:                                    ; COME HERE BEFORE EACH
                                                                        ; 256 BYTE BLOCK IS READ
F8E9 C7066900FFFF                       MOV     CRC_REG,0FFFFH          ; INIT CRC REG
F8EF BA0001                             MOV     DX,256                  ; SET DX TO DATA BLOCK SIZE
F8F2                            W11:                                    ; RD_BLK
F8F2 F606710080                         TEST    BIOS_BREAK, 80H         ; CHECK FOR BREAK KEY
F8F7 7523                               JNZ     W13                     ; JUMP IF BREAK KEY HIT
F8F9 E84F00                             CALL    READ_BYTE               ; READ BYTE FROM CASSETTE
F8FC 721E                               JC      W13                     ; CY SET INDICATES NO DATA TRANSITIONS
F8FE E305                               JCXZ    W12                     ; IF WE'VE ALREADY REACHED
                                                                        ; END OF MEMORY BUFFER
                                                                        ; SKIP REST OF BLOCK
F900 268807                             MOV     ES:[BX],AL              ; STORE DATA BYTE AT BYTE PTR
F903 43                                 INC     BX                      ; INC BUFFER PTR
F904 49                                 DEC     CX                      ; DEC BYTE COUNTER
F905                            W12:                                    ; LOOP UNTIL DATA BLOCK HAS BEEN
                                                                        ;  READ FROM CASSETTE.
F905 4A                                 DEC     DX                      ; DEC BLOCK CNT
F906 7FEA                               JG      W11                     ; RD_BLK
F908 E84000                             CALL    READ_BYTE               ; NOW READ TWO CRC BYTES
F90B E83D00                             CALL    READ_BYTE
F90E 2AE4                               SUB     AH,AH                   ; CLEAR AH
F910 813E69000F1D                       CMP     CRC_REG,1D0FH           ; IS THE CRC CORRECT
F916 7506                               JNE     W14                     ; IF NOT EQUAL CRC IS BAD
F918 E306                               JCXZ    W15                     ; IF BYTE COUNT IS ZERO
                                                                        ; THEN WE HAVE READ ENOUGH
                                                                        ; SO WE WILL EXIT
F91A EBCD                               JMP     W10                     ; STILL MORE, SO READ ANOTHER BLOCK
F91C                            W13:                                    ; MISSING-DATA
                                                                        ; NO DATA TRANSITIONS SO
F91C B401                               MOV     AH,01H                  ; SET AH=02 TO INDICATE
                                                                        ; DATA TIMEOUT
F91E                            W14:                                    ; BAD-CRC
F91E FEC4                               INC     AH                      ; EXIT EARLY ON ERROR
                                                                        ; SET AH=01 TO INDICATE CRC ERROR
F920                            W15:                                    ; RD-BLK-EX
F920 5A                                 POP     DX                      ; CALCULATE COUNT OF
F921 2BD1                               SUB     DX,CX                   ; DATA BYTES ACTUALLY READ
                                                                        ; RETURN COUNT IN REG DX
F923 50                                 PUSH    AX                      ; SAVE AX (RET CODE)
F924 F6C490                             TEST    AH, 90H                 ; CHECK FOR ERRORS
F927 7513                               JNZ     W18                     ; JUMP IF ERROR DETECTED
F929 E81F00                             CALL    READ_BYTE               ; READ TRAILER
F92C EB0E                               JMP     SHORT W18               ; SKIP TO TURN OFF MOTOR
F92E                            W16:                                    ; BAD-LEADER
F92E 4E                                 DEC     SI                      ; CHECK RETRIES
F92F 7403                               JZ      W17                     ; JUMP IF TOO MANY RETRIES
F931 E965FF                             JMP     W4                      ; JUMP IF NOT TOO MANY RETRIES
F934                            W17:                                    ; NO VALID DATA FOUND

                                ;----- NO DATA FROM CASSETTE ERROR, I.E. TIMEOUT

F934 5E                                 POP     SI                      ; RESTORE REGS
F935 59                                 POP     CX                      ; RESTORE REGS
F936 5B                                 POP     BX
F937 2BD2                               SUB     DX,DX                   ; ZERO NUMBER OF BYTES READ
F939 B404                               MOV     AH,04H                  ; TIME OUT ERROR (NO LEADER)
F93B 50                                 PUSH    AX
F93C                            W18:                                    ; MOT-OFF
```

```
F93C E421                   IN      AL, 021H             ; RE_ENABLE INTERRUPTS
F93E 24FE                   AND     AL, 0FFH- 1
F940 E621                   OUT     021H, AL
F942 E845FF                 CALL    MOTOR_OFF            ; TURN OFF MOTOR
F945 58                     POP     AX                   ; RESTORE RETURN CODE
F946 80FC01                 CMP     AH,01H               ; SET CARRY IF ERROR (AH>0)
F949 F5                     CMC
F94A C3                     RET                          ; FINISHED
                    READ_BLOCK      ENDP
                    ;--------------------------------------
                    ; PURPOSE:                            :
                    ;       TO READ A BYTE FROM CASSETTE  :
                    ; ON EXIT                             :
                    ;       REG AL CONTAINS READ DATA BYTE :
                    ;--------------------------------------
F94B                READ_BYTE       PROC    NEAR
F94B 53                     PUSH    BX                   ; SAVE REGS BX,CX
F94C 51                     PUSH    CX
F94D B108                   MOV     CL,8H                ; SET BIT COUNTER FOR 8 BITS
F94F                W19:                                 ; BYTE-ASM
F94F 51                     PUSH    CX                   ; SAVE CX
                    ;-------------------------------
                    ; READ DATA BIT FROM CASSETTE   :
                    ;-------------------------------
F950 E82600                 CALL    READ_HALF_BIT        ; READ ONE PULSE
F953 E320                   JCXZ    W21                  ; IF CX=0 THEN TIMEOUT
                                                         ; BECAUSE OF NO DATA TRANSITIONS
F955 53                     PUSH    BX                   ; SAVE 1ST HALF BIT'S
                                                         ; PULSE WIDTH (IN BX)
F956 E82000                 CALL    READ_HALF_BIT        ; READ COMPLEMENTARY PULSE
F959 58                     POP     AX                   ; COMPUTE DATA BIT
F95A E319                   JCXZ    W21                  ; IF CX=0 THEN TIMEOUT DUE TO
                                                         ; NO DATA TRANSITIONS
F95C 03D8                   ADD     BX,AX                ; PERIOD
F95E 81FBF006               CMP     BX, 06F0H            ; CHECK FOR ZERO BIT
F962 F5                     CMC                          ; CARRY IS SET IF ONE BIT
F963 9F                     LAHF                         ; SAVE CARRY IN AH
F964 59                     POP     CX                   ; RESTORE CX
                                                         ; NOTE:
                                                         ;  MS BIT OF BYTE IS READ FIRST.
                                                         ;  REG CH IS SHIFTED LEFT WITH
                                                         ;  CARRY BEING INSERTED INTO LS
                                                         ;   BIT OF CH.
                                                         ; AFTER ALL 8 BITS HAVE BEEN
                                                         ;   READ, THE MS BIT OF THE DATA BYTE
                                                         ;   WILL BE IN THE MS BIT OF REG CH
F965 D0D5                   RCL     CH,1                 ; ROTATE REG CH LEFT WITH CARRY TO
                                                         ;   LS BIT OF REG CH
F967 9E                     SAHF                         ; RESTORE CARRY FOR CRC ROUTINE
F968 E8D900                 CALL    CRC_GEN              ; GENERATE CRC FOR BIT
F96B FEC9                   DEC     CL                   ; LOOP TILL ALL 8 BITS OF DATA
                                                         ; ASSEMBLED IN REG CH
F96D 75E0                   JNZ     W19                  ; BYTE_ASM
F96F 8AC5                   MOV     AL,CH                ; RETURN DATA BYTE IN REG AL
F971 F8                     CLC
F972                W20:                                 ; RD-BYT-EX
F972 59                     POP     CX                   ; RESTORE REGS CX,BX
F973 5B                     POP     BX
F974 C3                     RET                          ; FINISHED
F975                W21:                                 ; NO-DATA
F975 59                     POP     CX                   ; RESTORE CX
F976 F9                     STC                          ; INDICATE ERROR
F977 EBF9                   JMP     W20                  ; RD_BYT_EX
                    READ_BYTE       ENDP
                    ;---------------------------------------------
                    ; PURPOSE:                                   :
                    ;       TO COMPUTE TIME TILL NEXT DATA       :
                    ;       TRANSITION (EDGE)                    :
                    ; ON ENTRY:                                  :
                    ;       EDGE_CNT CONTAINS LAST EDGE COUNT    :
                    ; ON EXIT:                                   :
                    ;       AX CONTAINS OLD LAST EDGE COUNT      :
                    ;       BX CONTAINS PULSE WIDTH (HALF BIT)   :
                    ;---------------------------------------------
F979                READ_HALF_BIT   PROC    NEAR
F979 B96400                 MOV     CX, 100              ; SET TIME TO WAIT FOR BIT
F97C 8A266B00               MOV     AH,LAST_VAL          ; GET PRESENT INPUT VALUE
```

Section 5

```
LOC OBJ                 SOURCE

F980                    W22:                                    ; RD-H-BIT
F980 E462                       IN      AL,PORT_C               ; INPUT DATA BIT
F982 2410                       AND     AL,010H                 ; MASK OFF EXTRANEOUS BITS
F984 3AC4                       CMP     AL,AH                   ; SAME AS BEFORE?
F986 E1F8                       LOOPE   W22                     ; LOOP TILL IT CHANGES
F988 A26B00                     MOV     LAST_VAL,AL             ; UPDATE LAST_VAL WITH NEW VALUE
F98B B000                       MOV     AL,0                    ; READ TIMER'S COUNTER COMMAND
F98D E643                       OUT     TIM_CTL,AL              ; LATCH COUNTER
F98F 8B1E6700                   MOV     BX,EDGE_CNT             ; BX GETS LAST EDGE COUNT
F993 E440                       IN      AL,TIMER0               ; GET LS BYTE
F995 8AE0                       MOV     AH,AL                   ; SAVE IN AH
F997 E440                       IN      AL,TIMER0               ; GET MS BYTE
F999 86C4                       XCHG    AL,AH                   ; XCHG AL,AH
F99B 2BD8                       SUB     BX,AX                   ; SET BX EQUAL TO HALF BIT PERIOD
F99D A36700                     MOV     EDGE_CNT,AX             ; UPDATE EDGE COUNT;
F9A0 C3                         RET
                        READ_HALF_BIT   ENDP
                        ;--------------------------------------------------------------
                        ; PURPOSE                                                      :
                        ;       WRITE 1 OR MORE 256 BYTE BLOCKS TO CASSETTE.           :
                        ;       THE DATA IS PADDED TO FILL OUT THE LAST 256 BYTE BLOCK. :
                        ; ON ENTRY:                                                    :
                        ;       BX POINTS TO MEMORY BUFFER ADDRESS                     :
                        ;       CX CONTAINS NUMBER OF BYTES TO WRITE                   :
                        ; ON EXIT:                                                     :
                        ;       BX POINTS 1 BYTE PAST LAST BYTE WRITTEN TO CASSETTE    :
                        ;       CX IS ZERO                                             :
                        ;--------------------------------------------------------------
F9A1                    WRITE_BLOCK     PROC    NEAR
F9A1 53                         PUSH    BX
F9A2 51                         PUSH    CX
F9A3 E461                       IN      AL,PORT_B               ; DISABLE SPEAKER
F9A5 24FD                       AND     AL,NOT 02H
F9A7 0C01                       OR      AL, 01H                 ; ENABLE TIMER
F9A9 E661                       OUT     PORT_B,AL
F9AB B0B6                       MOV     AL,0B6H                 ; SET UP TIMER -- MODE 3 SQUARE WAVE
F9AD E643                       OUT     TIM_CTL,AL
F9AF E8A600                     CALL    BEGIN_OP                ; START MOTOR AND DELAY
F9B2 B8A004                     MOV     AX,1184                 ; SET NORMAL BIT SIZE
F9B5 E88500                     CALL    W31                     ; SET_TIMER
F9B8 B90008                     MOV     CX,0800H                ; SET CX FOR LEADER BYTE COUNT
F9BB                    W23:                                    ; WRITE LEADER
F9BB F9                         STC                             ; WRITE ONE BITS
F9BC E86800                     CALL    WRITE_BIT
F9BF E2FA                       LOOP    W23                     ; LOOP 'TIL LEADER IS WRITTEN
F9C1 F8                         CLC                             ; WRITE SYNC BIT (0)
F9C2 E86200                     CALL    WRITE_BIT
F9C5 59                         POP     CX                      ; RESTORE REGS CX,BX
F9C6 5B                         POP     BX
F9C7 B016                       MOV     AL, 16H                 ; WRITE SYN CHARACTER
F9C9 E84400                     CALL    WRITE_BYTE
                        ;--------------------------------------------------------------
                        ; PURPOSE                                                      :
                        ;       WRITE 1 OR MORE 256 BYTE BLOCKS TO CASSETTE            :
                        ; ON ENTRY:                                                    :
                        ;       BX POINTS TO MEMORY BUFFER ADDRESS                     :
                        ;       CONTAINS NUMBER OF BYTES TO WRITE                      :
                        ; ON EXIT:                                                     :
                        ;       BX POINTS 1 BYTE PAST LAST BYTE WRITTEN TO CASSETTE    :
                        ;       CX IS ZERO                                             :
                        ;--------------------------------------------------------------
F9CC                    WR_BLOCK:
F9CC C7066900FFFF               MOV     CRC_REG,0FFFFH          ; INIT CRC
F9D2 BA0001                     MOV     DX,256                  ; FOR 256 BYTES
F9D5                    W24:                                    ; WR-BLK
F9D5 268A07                     MOV     AL,ES:[BX]              ; READ BYTE FROM MEM
F9D8 E83500                     CALL    WRITE_BYTE              ; WRITE IT TO CASSETTE
F9DB E302                       JCXZ    W25                     ; UNLESS CX=0, ADVANCE PTRS & DEC COUNT
F9DD 43                         INC     BX                      ; INC BUFFER POINTER
F9DE 49                         DEC     CX                      ; DEC BYTE COUNTER
F9DF                    W25:                                    ; SKIP-ADV
F9DF 4A                         DEC     DX                      ; DEC BLOCK CNT
F9E0 7FF3                       JG      W24                     ; LOOP TILL 256 BYTE BLOCK
                                                                ;  IS WRITTEN TO TAPE
                        ;--------------------------------------------------------------
                        ; WRITE CRC                                                    :
                        ;       WRITE 1'S COMPLEMENT OF CRC REG TO CASSETTE            :
```

```
LOC OBJ              SOURCE

                     ;       WHICH IS CHECKED FOR CORRECTNESS WHEN THE BLOCK IS READ :
                     ; REG AX IS MODIFIED                                              :
                     ;----------------------------------------------------------------
F9E2 A16900                  MOV     AX,CRC_REG              ; WRITE THE ONE'S COMPLEMENT OF THE
                                                             ;  TWO BYTE CRC TO TAPE
F9E5 F7D0                    NOT     AX                      ; FOR 1'S COMPLEMENT
F9E7 50                      PUSH    AX                      ; SAVE IT
F9E8 86E0                    XCHG    AH,AL                   ; WRITE MS BYTE FIRST
F9EA E82300                  CALL    WRITE_BYTE              ; WRITE IT
F9ED 58                      POP     AX                      ; GET IT BACK
F9EE E81F00                  CALL    WRITE_BYTE              ; NOW WRITE LS BYTE
F9F1 0BC9                    OR      CX,CX                   ; IS BYTE COUNT EXHAUSTED?
F9F3 75D7                    JNZ     WR_BLOCK                ; JUMP IF NOT DONE YET
F9F5 51                      PUSH    CX                      ; SAVE REG CX
F9F6 B92000                  MOV     CX, 32                  ; WRITE OUT TRAILER BITS
F9F9                 W26:                                    ; TRAIL-LOOP
F9F9 F9                      STC
F9FA E82A00                  CALL    WRITE_BIT
F9FD E2FA                    LOOP    W26                     ; WRITE UNTIL TRAILER WRITTEN
F9FF 59                      POP     CX                      ; RESTORE REG CX
FA00 B0B0                    MOV     AL, 0B0H                ; TURN TIMER2 OFF
FA02 E643                    OUT     TIM_CTL, AL
FA04 B80100                  MOV     AX, 1
FA07 E83300                  CALL    W31                     ; SET_TIMER
FA0A E87DFE                  CALL    MOTOR_OFF               ; TURN MOTOR OFF
FA0D 2BC0                    SUB     AX,AX                   ; NO ERRORS REPORTED ON WRITE OP
FA0F C3                      RET                             ; FINISHED
                     WRITE_BLOCK     ENDP
                     ;--------------------------------
                     ; WRITE A BYTE TO CASSETTE.      :
                     ; BYTE TO WRITE IS IN REG AL.    :
                     ;--------------------------------
FA10                 WRITE_BYTE      PROC    NEAR
FA10 51                      PUSH    CX                      ; SAVE REGS CX,AX
FA11 50                      PUSH    AX
FA12 8AE8                    MOV     CH,AL                   ; AL=BYTE TO WRITE.
                                                             ;   (MS BIT WRITTEN FIRST)
FA14 B108                    MOV     CL,8                    ; FOR 8 DATA BITS IN BYTE.
                                                             ;   NOTE: TWO EDGES PER BIT
FA16                 W27:                                    ; DISASSEMBLE THE DATA BIT
FA16 D0D5                    RCL     CH,1                    ; ROTATE MS BIT INTO CARRY
FA18 9C                      PUSHF                           ; SAVE FLAGS.
                                                             ;   NOTE: DATA BIT IS IN CARRY
FA19 E80B00                  CALL    WRITE_BIT               ; WRITE DATA BIT
FA1C 9D                      POPF                            ; RESTORE CARRY FOR CRC CALC
FA1D E82400                  CALL    CRC_GEN                 ; COMPUTE CRC ON DATA BIT
FA20 FEC9                    DEC     CL                      ; LOOP TILL ALL 8 BITS DONE
FA22 75F2                    JNZ     W27                     ; JUMP IF NOT DONE YET
FA24 58                      POP     AX                      ; RESTORE REGS AX,CX
FA25 59                      POP     CX
FA26 C3                      RET                             ; WE ARE FINISHED
                     WRITE_BYTE      ENDP
                     ;-----------------------------------------------------
                     ; PURPOSE:                                            :
                     ;       TO WRITE A DATA BIT TO CASSETTE               :
                     ;       CARRY FLAG CONTAINS DATA BIT                  :
                     ;       I.E. IF SET DATA BIT IS A ONE                 :
                     ;       IF CLEAR DATA BIT IS A ZERO                   :
                     ;                                                     :
                     ;  NOTE: TWO EDGES ARE WRITTEN PER BIT                :
                     ;        ONE BIT  HAS 500 USEC BETWEEN EDGES          :
                     ;             FOR A 1000 USEC PERIOD (1 MILLISEC)     :
                     ;                                                     :
                     ;        ZERO BIT HAS 250 USEC BETWEEN EDGES          :
                     ;             FOR A  500 USEC PERIOD (.5 MILLISEC)    :
                     ; CARRY FLAG IS DATA BIT                              :
                     ;-----------------------------------------------------
FA27                 WRITE_BIT       PROC    NEAR
                                                             ; ASSUME IT'S A '1'
FA27 B8A004                  MOV     AX,1184                 ; SET AX TO NOMINAL ONE SIZE
FA2A 7203                    JC      W28                     ; JUMP IF ONE BIT
FA2C B85002                  MOV     AX,592                  ; NO, SET TO NOMINAL ZERO SIZE
FA2F                 W28:                                    ; WRITE-BIT-AX
FA2F 50                      PUSH    AX                      ; WRITE BIT WITH PERIOD EQ TO VALUE AX
FA30                 W29:
FA30 E462                    IN      AL,PORT_C               ; INPUT TIMER_0 OUTPUT
FA32 2420                    AND     AL,020H
```

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LOC OBJ                     SOURCE

FA34 74FA                           JZ      W29                     ; LOOP TILL HIGH
FA36                        W30:
FA36 E462                           IN      AL,PORT_C               ; NOW WAIT TILL TIMER'S OUTPUT IS LOW
FA38 2420                           AND     AL,020H
FA3A 75FA                           JNZ     W30
                                                                    ; RELOAD TIMER WITH PERIOD
                                                                    ; FOR NEXT DATA BIT
FA3C 58                             POP     AX                      ; RESTORE PERIOD COUNT
FA3D                        W31:                                    ; SET TIMER
FA3D E642                           OUT     042H, AL                ; SET LOW BYTE OF TIMER 2
FA3F 8AC4                           MOV     AL, AH
FA41 E642                           OUT     042H, AL                ; SET HIGH BYTE OF TIMER 2
FA43 C3                             RET
                            WRITE_BIT       ENDP
                            ;-----------------------------------------------
                            ;  UPDATE CRC REGISTER WITH NEXT DATA BIT      :
                            ;  CRC IS USED TO DETECT READ ERRORS           :
                            ;  ASSUMES DATA BIT IS IN CARRY                :
                            ;                                              :
                            ;  REG AX IS MODIFIED                          :
                            ;  FLAGS ARE MODIFIED                          :
                            ;-----------------------------------------------
FA44                        CRC_GEN         PROC    NEAR
FA44 A16900                         MOV     AX,CRC_REG
                                                                    ; THE FOLLOWING INSTUCTIONS
                                                                    ; WILL SET THE OVERFLOW FLAG
                                                                    ; IF CARRY AND MS BIT OF CRC
                                                                    ; ARE UNEQUAL
FA47 D1D8                           RCR     AX,1
FA49 D1D0                           RCL     AX,1
FA4B F8                             CLC                             ; CLEAR CARRY
FA4C 7104                           JNO     W32                     ; SKIP IF NO OVERFLOW
                                                                    ; IF DATA BIT XORED WITH
                                                                    ;  CRC REG BIT 15 IS ONE
FA4E 351008                         XOR     AX,0810H                ; THEN XOR CRC REG WITH 0801H
FA51 F9                             STC                             ; SET CARRY
FA52                        W32:
FA52 D1D0                           RCL     AX,1                    ; ROTATE CARRY (DATA BIT)
                                                                    ; INTO CRC REG
FA54 A36900                         MOV     CRC_REG,AX              ; UPDATE CRC_REG
FA57 C3                             RET                             ; FINISHED
                            CRC_GEN         ENDP

FA58                        BEGIN_OP        PROC    NEAR            ; START TAPE AND DELAY
FA58 E826FE                         CALL    MOTOR_ON                ;TURN ON MOTOR
FA5B B342                           MOV     BL,42H                  ;DELAY FOR TAPE DRIVE
                                                                    ;TO GET UP TO SPEED  (1/2 SEC)
FA5D                        W33:
FA5D B90007                         MOV     CX,700H                 ;INNER LOOP= APPROX. 10 MILLISEC
FA60 E2FE                   W34:    LOOP    W34
FA62 FECB                           DEC     BL
FA64 75F7                           JNZ     W33
FA66 C3                             RET
                            BEGIN_OP        ENDP

FA67 20323031               E1      DB      ' 201',13,10
FA6B 0D
FA6C 0A

                            ;----------------------------------------------------------------------
                            ;       CHARACTER GENERATOR GRAPHICS FOR 320X200 AND 640X200 GRAPHICS
                            ;----------------------------------------------------------------------
FA6E                                ORG     0FA6EH
FA6E                        CRT_CHAR_GEN    LABEL   BYTE
FA6E 0000000000000000               DB      000H,000H,000H,000H,000H,000H,000H,000H ; D_00
FA76 7E81A581BD99817E               DB      07EH,081H,0A5H,081H,0BDH,099H,081H,07EH ; D_01
FA7E 7EFFDBFFC3E7FF7E               DB      07EH,0FFH,0DBH,0FFH,0C3H,0E7H,0FFH,07EH ; D_02
FA86 6CFEFEFE7C381000               DB      06CH,0FEH,0FEH,0FEH,07CH,038H,010H,000H ; D_03
FA8E 10387CFE7C381000               DB      010H,038H,07CH,0FEH,07CH,038H,010H,000H ; D_04
FA96 387C38FEFE7C387C               DB      038H,07CH,038H,0FEH,0FEH,07CH,038H,07CH ; D_05
FA9E 1010387CFE7C387C               DB      010H,010H,038H,07CH,0FEH,07CH,038H,07CH ; D_06
FAA6 0000183C3C180000               DB      000H,000H,018H,03CH,03CH,018H,000H,000H ; D_07
FAAE FFFFE7C3C3E7FFFF               DB      0FFH,0FFH,0E7H,0C3H,0C3H,0E7H,0FFH,0FFH ; D_08
FAB6 003C664242663C00               DB      000H,03CH,066H,042H,042H,066H,03CH,000H ; D_09
FABE FFC399BDBD99C3FF               DB      0FFH,0C3H,099H,0BDH,0BDH,099H,0C3H,0FFH ; D_0A
FAC6 0F070F7DCCCCCC78               DB      00FH,007H,00FH,07DH,0CCH,0CCH,0CCH,078H ; D_0B
FACE 3C6666663C187E18               DB      03CH,066H,066H,066H,03CH,018H,07EH,018H ; D_0C
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LOC OBJ                 LINE    SOURCE

FAD6 3F333F303070F0E0   5787        DB      03FH,033H,03FH,030H,030H,070H,0F0H,0E0H ; D_0D
FADE 7F637F636367E6C0   5788        DB      07FH,063H,07FH,063H,063H,067H,0E6H,0C0H ; D_0E
FAE6 995A3CE7E73C5A99   5789        DB      099H,05AH,03CH,0E7H,0E7H,03CH,05AH,099H ; D_0F
FAEE 80E0F8FEF8E08000   5790        DB      080H,0E0H,0F8H,0FEH,0F8H,0E0H,080H,000H ; D_10
FAF6 020E3EFE3E0E0200   5791        DB      002H,00EH,03EH,0FEH,03EH,00EH,002H,000H ; D_11
FAFE 183C7E18187E3C18   5792        DB      018H,03CH,07EH,018H,018H,07EH,03CH,018H ; D_12
FB06 6666666666006600   5793        DB      066H,066H,066H,066H,066H,000H,066H,000H ; D_13
FB0E 7FDBDB7B1B1B1B00   5794        DB      07FH,0DBH,0DBH,07BH,01BH,01BH,01BH,000H ; D_14
FB16 3E63386C6C38CC78   5795        DB      03EH,063H,038H,06CH,06CH,038H,0CCH,078H ; D_15
FB1E 000000007E7E7E00   5796        DB      000H,000H,000H,000H,07EH,07EH,07EH,000H ; D_16
FB26 183C7E187E3C18FF   5797        DB      018H,03CH,07EH,018H,07EH,03CH,018H,0FFH ; D_17
FB2E 183C7E1818181800   5798        DB      018H,03CH,07EH,018H,018H,018H,018H,000H ; D_18
FB36 181818187E3C1800   5799        DB      018H,018H,018H,018H,07EH,03CH,018H,000H ; D_19
FB3E 00180CFE0C180000   5800        DB      000H,018H,00CH,0FEH,00CH,018H,000H,000H ; D_1A
FB46 003060FE60300000   5801        DB      000H,030H,060H,0FEH,060H,030H,000H,000H ; D_1B
FB4E 0000C0C0C0FE0000   5802        DB      000H,000H,0C0H,0C0H,0C0H,0FEH,000H,000H ; D_1C
FB56 002466FF66240000   5803        DB      000H,024H,066H,0FFH,066H,024H,000H,000H ; D_1D
FB5E 00183C7EFFFF0000   5804        DB      000H,018H,03CH,07EH,0FFH,0FFH,000H,000H ; D_1E
FB66 00FFFF7E3C180000   5805        DB      000H,0FFH,0FFH,07EH,03CH,018H,000H,000H ; D_1F
FB6E 0000000000000000   5806        DB      000H,000H,000H,000H,000H,000H,000H,000H ; SP D_20
FB76 3078783030003000   5807        DB      030H,078H,078H,030H,030H,000H,030H,000H ; ! D_21
FB7E 6C6C6C0000000000   5808        DB      06CH,06CH,06CH,000H,000H,000H,000H,000H ; " D_22
FB86 6C6CFE6CFE6C6C00   5809        DB      06CH,06CH,0FEH,06CH,0FEH,06CH,06CH,000H ; # D_23
FB8E 307CC0780CF83000   5810        DB      030H,07CH,0C0H,078H,00CH,0F8H,030H,000H ; $ D_24
FB96 00C6CC183066C600   5811        DB      000H,0C6H,0CCH,018H,030H,066H,0C6H,000H ; PER CENT D_25
FB9E 386C3876DCCC7600   5812        DB      038H,06CH,038H,076H,0DCH,0CCH,076H,000H ; & D_26
FBA6 6060C00000000000   5813        DB      060H,060H,0C0H,000H,000H,000H,000H,000H ; ' D_27
FBAE 1830606060301800   5814        DB      018H,030H,060H,060H,060H,030H,018H,000H ; ( D_28
FBB6 6030181818306000   5815        DB      060H,030H,018H,018H,018H,030H,060H,000H ; ) D_29
FBBE 00663CFF3C660000   5816        DB      000H,066H,03CH,0FFH,03CH,066H,000H,000H ; * D_2A
FBC6 003030FC30300000   5817        DB      000H,030H,030H,0FCH,030H,030H,000H,000H ; + D_2B
FBCE 0000000000303060   5818        DB      000H,000H,000H,000H,000H,030H,030H,060H ; , D_2C
FBD6 000000FC00000000   5819        DB      000H,000H,000H,0FCH,000H,000H,000H,000H ; - D_2D
FBDE 0000000000303000   5820        DB      000H,000H,000H,000H,000H,030H,030H,000H ; . D_2E
FBE6 060C183060C08000   5821        DB      006H,00CH,018H,030H,060H,0C0H,080H,000H ; / D_2F
FBEE 7CC6CEDEF6E67C00   5822        DB      07CH,0C6H,0CEH,0DEH,0F6H,0E6H,07CH,000H ; 0 D_30
FBF6 307030303030FC00   5823        DB      030H,070H,030H,030H,030H,030H,0FCH,000H ; 1 D_31
FBFE 78CC0C3860CCFC00   5824        DB      078H,0CCH,00CH,038H,060H,0CCH,0FCH,000H ; 2 D_32
FC06 78CC0C380CCC7800   5825        DB      078H,0CCH,00CH,038H,00CH,0CCH,078H,000H ; 3 D_33
FC0E 1C3C6CCCFE0C1E00   5826        DB      01CH,03CH,06CH,0CCH,0FEH,00CH,01EH,000H ; 4 D_34
FC16 FCC0F80C0CCC7800   5827        DB      0FCH,0C0H,0F8H,00CH,00CH,0CCH,078H,000H ; 5 D_35
FC1E 3860C0F8CCCC7800   5828        DB      038H,060H,0C0H,0F8H,0CCH,0CCH,078H,000H ; 6 D_36
FC26 FCCC0C1830303000   5829        DB      0FCH,0CCH,00CH,018H,030H,030H,030H,000H ; 7 D_37
FC2E 78CCCC78CCCC7800   5830        DB      078H,0CCH,0CCH,078H,0CCH,0CCH,078H,000H ; 8 D_38
FC36 78CCCC7C0C187000   5831        DB      078H,0CCH,0CCH,07CH,00CH,018H,070H,000H ; 9 D_39
FC3E 0030300000303000   5832        DB      000H,030H,030H,000H,000H,030H,030H,000H ; : D_3A
FC46 0030300000303060   5833        DB      000H,030H,030H,000H,000H,030H,030H,060H ; ; D_3B
FC4E 183060C060301800   5834        DB      018H,030H,060H,0C0H,060H,030H,018H,000H ; < D_3C
FC56 0000FC0000FC0000   5835        DB      000H,000H,0FCH,000H,000H,0FCH,000H,000H ; = D_3D
FC5E 6030180C18306000   5836        DB      060H,030H,018H,00CH,018H,030H,060H,000H ; > D_3E
FC66 78CC0C1830003000   5837        DB      078H,0CCH,00CH,018H,030H,000H,030H,000H ; ? D_3F
FC6E 7CC6DEDEDEC07800   5838        DB      07CH,0C6H,0DEH,0DEH,0DEH,0C0H,078H,000H ; @ D_40
FC76 3078CCCCFCCCCC00   5839        DB      030H,078H,0CCH,0CCH,0FCH,0CCH,0CCH,000H ; A D_41
FC7E FC66667C6666FC00   5840        DB      0FCH,066H,066H,07CH,066H,066H,0FCH,000H ; B D_42
FC86 3C66C0C0C0663C00   5841        DB      03CH,066H,0C0H,0C0H,0C0H,066H,03CH,000H ; C D_43
FC8E F86C6666666CF800   5842        DB      0F8H,06CH,066H,066H,066H,06CH,0F8H,000H ; D D_44
FC96 FE6268786862FE00   5843        DB      0FEH,062H,068H,078H,068H,062H,0FEH,000H ; E D_45
FC9E FE6268786860F000   5844        DB      0FEH,062H,068H,078H,068H,060H,0F0H,000H ; F D_46
FCA6 3C66C0C0CE663E00   5845        DB      03CH,066H,0C0H,0C0H,0CEH,066H,03EH,000H ; G D_47
FCAE CCCCCCFCCCCCCC00   5846        DB      0CCH,0CCH,0CCH,0FCH,0CCH,0CCH,0CCH,000H ; H D_48
FCB6 7830303030307800   5847        DB      078H,030H,030H,030H,030H,030H,078H,000H ; I D_49
FCBE 1E0C0C0CCCCC7800   5848        DB      01EH,00CH,00CH,00CH,0CCH,0CCH,078H,000H ; J D_4A
FCC6 E6666C786C66E600   5849        DB      0E6H,066H,06CH,078H,06CH,066H,0E6H,000H ; K D_4B
FCCE F06060606266FE00   5850        DB      0F0H,060H,060H,060H,062H,066H,0FEH,000H ; L D_4C
FCD6 C6EEFEFED6C6C600   5851        DB      0C6H,0EEH,0FEH,0FEH,0D6H,0C6H,0C6H,000H ; M D_4D
FCDE C6E6F6DECEC6C600   5852        DB      0C6H,0E6H,0F6H,0DEH,0CEH,0C6H,0C6H,000H ; N D_4E
FCE6 386CC6C6C66C3800   5853        DB      038H,06CH,0C6H,0C6H,0C6H,06CH,038H,000H ; O D_4F
FCEE FC66667C6060F000   5854        DB      0FCH,066H,066H,07CH,060H,060H,0F0H,000H ; P D_50
FCF6 78CCCCCCDC781C00   5855        DB      078H,0CCH,0CCH,0CCH,0DCH,078H,01CH,000H ; Q D_51
FCFE FC66667C6C66E600   5856        DB      0FCH,066H,066H,07CH,06CH,066H,0E6H,000H ; R D_52
FD06 78CCE0701CCC7800   5857        DB      078H,0CCH,0E0H,070H,01CH,0CCH,078H,000H ; S D_53
FD0E FCB4303030307800   5858        DB      0FCH,0B4H,030H,030H,030H,030H,078H,000H ; T D_54
FD16 CCCCCCCCCCCCFC00   5859        DB      0CCH,0CCH,0CCH,0CCH,0CCH,0CCH,0FCH,000H ; U D_55
FD1E CCCCCCCCCC783000   5860        DB      0CCH,0CCH,0CCH,0CCH,0CCH,078H,030H,000H ; V D_56
FD26 C6C6C6D6FEEEC600   5861        DB      0C6H,0C6H,0C6H,0D6H,0FEH,0EEH,0C6H,000H ; W D_57
FD2E C6C66C38386CC600   5862        DB      0C6H,0C6H,06CH,038H,038H,06CH,0C6H,000H ; X D_58
FD36 CCCCCC7830307800   5863        DB      0CCH,0CCH,0CCH,078H,030H,030H,078H,000H ; Y D_59
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FD3E FEC68C183266FE00          DB      0FEH,0C6H,08CH,018H,032H,066H,0FEH,000H ; Z D_5A
FD46 7860606060607800          DB      078H,060H,060H,060H,060H,060H,078H,000H ; [ D_5B
FD4E C06030180C060200          DB      0C0H,060H,030H,018H,00CH,006H,002H,000H ; BACKSLASH D_5C
FD56 7818181818187800          DB      078H,018H,018H,018H,018H,018H,078H,000H ; ] D_5D
FD5E 10386CC600000000          DB      010H,038H,06CH,0C6H,000H,000H,000H,000H ; CIRCUMFLEX D_5E
FD66 00000000000000FF          DB      000H,000H,000H,000H,000H,000H,000H,0FFH ; _ D_5F
FD6E 3030180000000000          DB      030H,030H,018H,000H,000H,000H,000H,000H ; ' D_60
FD76 0000780C7CCC7600          DB      000H,000H,078H,00CH,07CH,0CCH,076H,000H ; LOWER CASE A D_61
FD7E E060607C6666DC00          DB      0E0H,060H,060H,07CH,066H,066H,0DCH,000H ; L.C. B D_62
FD86 000078CCC0CC7800          DB      000H,000H,078H,0CCH,0C0H,0CCH,078H,000H ; L.C. C D_63
FD8E 1C0C0C7CCCCC7600          DB      01CH,00CH,00CH,07CH,0CCH,0CCH,076H,000H ; L.C. D D_64
FD96 000078CCFCC07800          DB      000H,000H,078H,0CCH,0FCH,0C0H,078H,000H ; L.C. E D_65
FD9E 386C60F06060F000          DB      038H,06CH,060H,0F0H,060H,060H,0F0H,000H ; L.C. F D_66
FDA6 000076CCCC7C0CF8          DB      000H,000H,076H,0CCH,0CCH,07CH,00CH,0F8H ; L.C. G D_67
FDAE E0606C766666E600          DB      0E0H,060H,06CH,076H,066H,066H,0E6H,000H ; L.C. H D_68
FDB6 3000703030307800          DB      030H,000H,070H,030H,030H,030H,078H,000H ; L.C. I D_69
FDBE 0C000C0C0CCCCC78          DB      00CH,000H,00CH,00CH,00CH,0CCH,0CCH,078H ; L.C. J D_6A
FDC6 E060666C786CE600          DB      0E0H,060H,066H,06CH,078H,06CH,0E6H,000H ; L.C. K D_6B
FDCE 7030303030307800          DB      070H,030H,030H,030H,030H,030H,078H,000H ; L.C. L D_6C
FDD6 0000CCFEFED6C600          DB      000H,000H,0CCH,0FEH,0FEH,0D6H,0C6H,000H ; L.C. M D_6D
FDDE 0000F8CCCCCCCC00          DB      000H,000H,0F8H,0CCH,0CCH,0CCH,0CCH,000H ; L.C. N D_6E
FDE6 000078CCCCCC7800          DB      000H,000H,078H,0CCH,0CCH,0CCH,078H,000H ; L.C. O D_6F
FDEE 0000DC66667C60F0          DB      000H,000H,0DCH,066H,066H,07CH,060H,0F0H ; L.C. P D_70
FDF6 000076CCCC7C0C1E          DB      000H,000H,076H,0CCH,0CCH,07CH,00CH,01EH ; L.C. Q D_71
FDFE 0000DC766660F000          DB      000H,000H,0DCH,076H,066H,060H,0F0H,000H ; L.C. R D_72
FE06 00007CC0780CF800          DB      000H,000H,07CH,0C0H,078H,00CH,0F8H,000H ; L.C. S D_73
FE0E 10307C3030341800          DB      010H,030H,07CH,030H,030H,034H,018H,000H ; L.C. T D_74
FE16 0000CCCCCCCC7600          DB      000H,000H,0CCH,0CCH,0CCH,0CCH,076H,000H ; L.C. U D_75
FE1E 0000CCCCCC783000          DB      000H,000H,0CCH,0CCH,0CCH,078H,030H,000H ; L.C. V D_76
FE26 0000C6D6FEFE6C00          DB      000H,000H,0C6H,0D6H,0FEH,0FEH,06CH,000H ; L.C. W D_77
FE2E 0000C66C386CC600          DB      000H,000H,0C6H,06CH,038H,06CH,0C6H,000H ; L.C. X D_78
FE36 0000CCCCCC7C0CF8          DB      000H,000H,0CCH,0CCH,0CCH,07CH,00CH,0F8H ; L.C. Y D_79
FE3E 0000FC983064FC00          DB      000H,000H,0FCH,098H,030H,064H,0FCH,000H ; L.C. Z D_7A
FE46 1C3030E030301C00          DB      01CH,030H,030H,0E0H,030H,030H,01CH,000H ; { D_7B
FE4E 1818180018181800          DB      018H,018H,018H,000H,018H,018H,018H,000H ; | D_7C
FE56 E030301C3030E000          DB      0E0H,030H,030H,01CH,030H,030H,0E0H,000H ; } D_7D
FE5E 76DC000000000000          DB      076H,0DCH,000H,000H,000H,000H,000H,000H ; TILDE D_7E
FE66 0010386CC6C6FE00          DB      000H,010H,038H,06CH,0C6H,0C6H,0FEH,000H ; DELTA D_7F

                       ;--- INT 1A -------------------------------------------
                       ; TIME_OF_DAY                                          :
                       ;  THIS ROUTINE ALLOWS THE CLOCK TO BE SET/READ        :
                       ;                                                      :
                       ; INPUT                                                :
                       ;   (AH) = 0     READ THE CURRENT CLOCK SETTING        :
                       ;                RETURNS CX = HIGH PORTION OF COUNT    :
                       ;                        DX = LOW PORTION OF COUNT     :
                       ;                        AL = 0 IF TIMER HAS NOT PASSED :
                       ;                         24 HOURS SINCE LAST READ     :
                       ;                           <>0 IF ON ANOTHER DAY      :
                       ;   (AH) = 1     SET THE CURRENT CLOCK                 :
                       ;        CX = HIGH PORTION OF COUNT                    :
                       ;        DX = LOW PORTION OF COUNT                     :
                       ; NOTE: COUNTS OCCUR AT THE RATE OF                    :
                       ;        1193180/65536 COUNTS/SEC                      :
                       ;        (OR ABOUT 18.2 PER SECOND -- SEE EQUATES BELOW) :
                       ;------------------------------------------------------
                               ASSUME  CS:CODE,DS:DATA
FE6E                           ORG     0FE6EH
FE6E                   TIME_OF_DAY     PROC    FAR
FE6E FB                        STI                             ; INTERRUPTS BACK ON
FE6F 1E                        PUSH    DS                      ; SAVE SEGMENT
FE70 E8CB00                    CALL    DDS
FE73 0AE4                      OR      AH,AH                   ; AH=0
FE75 7407                      JZ      T2                      ; READ_TIME
FE77 FECC                      DEC     AH                      ; AH=1
FE79 7416                      JZ      T3                      ; SET_TIME
FE7B                   T1:                                     ; TOD_RETURN
FE7B FB                        STI                             ; INTERRUPTS BACK ON
FE7C 1F                        POP     DS                      ; RECOVER SEGMENT
FE7D CF                        IRET                            ; RETURN TO CALLER
FE7E                   T2:                                     ; READ_TIME
FE7E FA                        CLI                             ; NO TIMER INTERRUPTS WHILE READING
FE7F A07000                    MOV     AL,TIMER_OFL
FE82 C606700000                MOV     TIMER_OFL,0             ; GET OVERFLOW, AND RESET THE FLAG
FE87 8B0E6E00                  MOV     CX,TIMER_HIGH
FE8B 8B166C00                  MOV     DX,TIMER_LOW
```

```
LOC OBJ                SOURCE

FE8F EBEA                     JMP     T1                  ; TOD_RETURN
FE91                   T3:                                ; SET_TIME
FE91 FA                       CLI                         ; NO INTERRUPTS WHILE WRITING
FE92 89166C00                 MOV     TIMER_LOW,DX
FE96 890E6E00                 MOV     TIMER_HIGH,CX       ; SET THE TIME
FE9A C606700000               MOV     TIMER_OFL,0         ; RESET OVERFLOW
FE9F EBDA                     JMP     T1                  ; TOD_RETURN
                       TIME_OF_DAY    ENDP

                       ;-----------------------------------------------------
                       ; THIS ROUTINE HANDLES THE TIMER INTERRUPT FROM        :
                       ;  CHANNEL 0 OF THE 8253 TIMER. INPUT FREQUENCY        :
                       ;  IS 1.19318 MHZ AND THE DIVISOR IS 65536, RESULTING  :
                       ;  IN APPROX. 18.2 INTERRUPTS EVERY SECOND.            :
                       ;                                                      :
                       ; THE INTERRUPT HANDLER MAINTAINS A COUNT OF INTERRUPTS :
                       ;  SINCE POWER ON TIME, WHICH MAY BE USED TO ESTABLISH :
                       ;  TIME OF DAY.                                        :
                       ; THE INTERRUPT HANDLER ALSO DECREMENTS THE MOTOR      :
                       ;  CONTROL COUNT OF THE DISKETTE, AND WHEN IT EXPIRES, :
                       ;  WILL TURN OFF THE DISKETTE MOTOR, AND RESET THE     :
                       ;  MOTOR RUNNING FLAGS.                                :
                       ; THE INTERRUPT HANDLER WILL ALSO INVOKE A USER ROUTINE :
                       ;  THROUGH INTERRUPT 1CH AT EVERY TIME TICK.  THE USER :
                       ;  MUST CODE A ROUTINE AND PLACE THE CORRECT ADDRESS IN :
                       ;  THE VECTOR TABLE.                                   :
                       ;-----------------------------------------------------
FEA5                          ORG     0FEA5H
FEA5                   TIMER_INT      PROC    FAR
FEA5 FB                       STI                         ; INTERRUPTS BACK ON
FEA6 1E                       PUSH    DS
FEA7 50                       PUSH    AX
FEA8 52                       PUSH    DX                  ; SAVE MACHINE STATE
FEA9 E89200                   CALL    DDS
FEAC FF066C00                 INC     TIMER_LOW           ; INCREMENT TIME
FEB0 7504                     JNZ     T4                  ; TEST_DAY
FEB2 FF066E00                 INC     TIMER_HIGH          ; INCREMENT HIGH WORD OF TIME
FEB6                   T4:                                ; TEST_DAY
FEB6 833E6E0018               CMP     TIMER_HIGH,018H     ; TEST FOR COUNT EQUALING 24 HOURS
FEBB 7515                     JNZ     T5                  ; DISKETTE_CTL
FEBD 813E6C00B000             CMP     TIMER_LOW,0B0H
FEC3 750D                     JNZ     T5                  ; DISKETTE_CTL

                       ;------ TIMER HAS GONE 24 HOURS

FEC5 2BC0                     SUB     AX,AX
FEC7 A36E00                   MOV     TIMER_HIGH,AX
FECA A36C00                   MOV     TIMER_LOW,AX
FECD C606700001               MOV     TIMER_OFL,1

                       ;------ TEST FOR DISKETTE TIME OUT

FED2                   T5:                                ; DISKETTE_CTL
FED2 FE0E4000                 DEC     MOTOR_COUNT
FED6 750B                     JNZ     T6                  ; RETURN IF COUNT NOT OUT
FED8 80263F00F0               AND     MOTOR_STATUS,0F0H   ; TURN OFF MOTOR RUNNING BITS
FEDD B00C                     MOV     AL,0CH
FEDF BAF203                   MOV     DX,03F2H            ; FDC CTL PORT
FEE2 EE                       OUT     DX,AL               ; TURN OFF THE MOTOR
FEE3                   T6:                                ; TIMER_RET:
FEE3 CD1C                     INT     1CH                 ; TRANSFER CONTROL TO A USER ROUTINE
FEE5 B020                     MOV     AL,EOI
FEE7 E620                     OUT     020H,AL             ; END OF INTERRUPT TO 8259
FEE9 5A                       POP     DX
FEEA 58                       POP     AX
FEEB 1F                       POP     DS                  ; RESET MACHINE STATE
FEEC CF                       IRET                        ; RETURN FROM INTERRUPT
                       TIMER_INT      ENDP

FEED 31383031          F3B    DB      '1801',13,10
FEF1 0D
FEF2 0A

                       ;--------------------------------------------------------------
                       ;       THESE ARE THE VECTORS WHICH ARE MOVED INTO            :
                       ;       THE 8086 INTERRUPT AREA DURING POWER ON.              :
                       ;       ONLY THE OFFSETS ARE DISPLAYED HERE, CODE SEGMENT     :
```

```
LOC OBJ                LINE  SOURCE

                             ;       WILL BE ADDED FOR ALL OF THEM, EXCEPT WHERE NOTED       :
                             ;----------------------------------------------------------------
                                     ASSUME  CS:CODE
FEF3                                 ORG     0FEF3H
FEF3                         VECTOR_TABLE    LABEL   WORD        ; VECTOR TABLE FOR MOVE TO INTERRUPTS
FEF3 A5FE                            DW      OFFSET TIMER_INT        ; INTERRUPT 8
FEF5 87E9                            DW      OFFSET  KB_INT          ; INTERRUPT 9
FEF7 DDE6                            DW      OFFSET D_EOI            ; INTERRUPT A
FEF9 DDE6                            DW      OFFSET D_EOI            ; INTERRUPT B
FEFB DDE6                            DW      OFFSET D_EOI            ; INTERRUPT C
FEFD DDE6                            DW      OFFSET D_EOI            ; INTERRUPT D
FEFF 57EF                            DW      OFFSET DISK_INT         ; INTERRUPT E
FF01 DDE6                            DW      OFFSET D_EOI            ; INTERRUPT F
FF03 65F0                            DW      OFFSET VIDEO_IO         ; INTERRUPT 10H
FF05 4DF8                            DW      OFFSET EQUIPMENT        ; INTERRUPT 11H
FF07 41F8                            DW      OFFSET MEMORY_SIZE_DET  ; INTERRUPT 12H
FF09 59EC                            DW      OFFSET DISKETTE_IO      ; INTERRUPT 13H
FF0B 39E7                            DW      OFFSET RS232_IO         ; INTERRUPT 14H
FF0D 59F8                            DW      OFFSET CASSETTE_IO      ; INTERRUPT 15H
FF0F 2EE8                            DW      OFFSET KEYBOARD_IO      ; INTERRUPT 16H
FF11 D2EF                            DW      OFFSET PRINTER_IO       ; INTERRUPT 17H

FF13 0000                            DW      00000H                  ; INTERRUPT 18H
                             ;       DW      0F600H                  ;  MUST BE INSERTED INTO TABLE LATER

FF15 F2E6                            DW      OFFSET BOOT_STRAP       ; INTERRUPT 19H
FF17 6EFE                            DW      TIME_OF_DAY             ; INTERRUPT 1AH -- TIME OF DAY
FF19 53FF                            DW      DUMMY_RETURN            ; INTERRUPT 1BH -- KEYBOARD BREAK ADDR
FF1B 53FF                            DW      DUMMY_RETURN            ; INTERRUPT 1C -- TIMER BREAK ADDR
FF1D A4F0                            DW      VIDEO_PARMS             ; INTERRUPT 1D -- VIDEO PARAMETERS
FF1F C7EF                            DW      OFFSET DISK_BASE        ; INTERRUPT 1E -- DISK PARMS
FF21 0000                            DW      0                       ; INTERRUPT 1F -- POINTER TO VIDEO EXT

FF23 50415249545920          D2      DB      'PARITY CHECK 1',13,10
     434845434B2031
FF31 0D
FF32 0A
FF33 20333031                F1      DB      ' 301',13,10
FF37 0D
FF38 0A
FF39 313331                  F2      DB      '131',13,10
FF3C 0D
FF3D 0A

FF3E                         DDS     PROC    NEAR
FF3E 50                              PUSH    AX                      ; SAVE AX
FF3F B84000                          MOV     AX,DATA
FF42 8ED8                            MOV     DS,AX                   ; SET DATA SEGMENT
FF44 58                              POP     AX                      ; RESTORE AX
FF45 C3                              RET
                             DDS     ENDP

                             ;-------------------------------------------------------
                             ;       TEMPORARY INTERRUPT SERVICE ROUTINE            :
                             ;-------------------------------------------------------
FF47                                 ORG     0FF47H
FF47                         D11     PROC    NEAR
FF47 B401                            MOV     AH,1
FF49 50                              PUSH    AX                      ; SAVE REG AX CONTENTS
FF4A B0FF                            MOV     AL,0FFH                 ; MASK ALL INTERRUPTS OFF
FF4C E621                            OUT     INTA01,AL
FF4E B020                            MOV     AL,EOI
FF50 E620                            OUT     INTA00,AL
FF52 58                              POP     AX                      ; RESTORE REG AX CONTENTS
FF53                         DUMMY_RETURN:                           ; NEED IRET FOR VECTOR TABLE
FF53 CF                              IRET
                             D11     ENDP

                             ;-- INT 5 -------------------------------------------------------------
                             ;       THIS LOGIC WILL BE INVOKED BY INTERRUPT 05H TO PRINT THE       :
                             ;       SCREEN. THE CURSOR POSITION AT THE TIME THIS ROUTINE IS INVOKED :
                             ;       WILL BE SAVED AND RESTORED UPON COMPLETION. THE ROUTINE IS     :
                             ;       INTENDED TO RUN WITH INTERRUPTS ENABLED. IF A SUBSEQUENT       :
                             ;       'PRINT SCREEN' KEY IS DEPRESSED DURING THE TIME THIS ROUTINE   :
                             ;       IS PRINTING IT WILL BE IGNORED.                                :
                             ;       ADDRESS 50:0 CONTAINS THE STATUS OF THE PRINT SCREEN:          :
                             ;                                                                      :
```

```
                   ;       50:0    =0      EITHER PRINT SCREEN HAS NOT BEEN CALLED        :
                   ;                       OR UPON RETURN FROM A CALL THIS INDICATES      :
                   ;                       A SUCCESSFUL OPERATION.                        :
                   ;               =1      PRINT SCREEN IS IN PROGRESS                    :
                   ;               =255    ERROR ENCOUNTERED DURING PRINTING              :
                   ;----------------------------------------------------------------------
                           ASSUME  CS:CODE,DS:XXDATA
FF54                       ORG     0FF54H
FF54               PRINT_SCREEN    PROC    FAR
FF54 FB                    STI                             ; MUST RUN WITH INTERRUPTS ENABLED
FF55 1E                    PUSH    DS                      ; MUST USE 50:0 FOR DATA AREA STORAGE
FF56 50                    PUSH    AX
FF57 53                    PUSH    BX
FF58 51                    PUSH    CX                      ; WILL USE THIS LATER FOR CURSOR LIMITS
FF59 52                    PUSH    DX                      ; WILL HOLD CURRENT CURSOR POSITION
FF5A B85000                MOV     AX,XXDATA               ; HEX 50
FF5D 8ED8                  MOV     DS,AX
FF5F 803E000001            CMP     STATUS_BYTE,1           ; SEE IF PRINT ALREADY IN PROGRESS
FF64 745F                  JZ      EXIT                    ; JUMP IF PRINT ALREADY IN PROGRESS
FF66 C606000001            MOV     STATUS_BYTE,1           ; INDICATE PRINT NOW IN PROGRESS
FF6B B40F                  MOV     AH,15                   ; WILL REQUEST THE CURRENT SCREEN MODE
FF6D CD10                  INT     10H                     ;       [AL]=MODE
                                                           ;       [AH]=NUMBER COLUMNS/LINE
                                                           ;       [BH]=VISUAL PAGE
                   ;--------------------------------------------------------------
                   ;       AT THIS POINT WE KNOW THE COLUMNS/LINE ARE IN          :
                   ;       [AX] AND THE PAGE IF APPLICABLE IS IN [BH]. THE STACK  :
                   ;       HAS DS,AX,BX,CX,DX PUSHED. [AL] HAS VIDEO MODE         :
                   ;--------------------------------------------------------------
FF6F 8ACC                  MOV     CL,AH                   ; WILL MAKE USE OF [CX] REGISTER TO
FF71 B519                  MOV     CH,25                   ; CONTROL ROW & COLUMNS
FF73 E85500                CALL    CRLF                    ; CARRIAGE RETURN LINE FEED ROUTINE
FF76 51                    PUSH    CX                      ; SAVE SCREEN BOUNDS
FF77 B403                  MOV     AH,3                    ; WILL NOW READ THE CURSOR.
FF79 CD10                  INT     10H                     ; AND PRESERVE THE POSITION
FF7B 59                    POP     CX                      ; RECALL SCREEN BOUNDS
FF7C 52                    PUSH    DX                      ; RECALL [BH]=VISUAL PAGE
FF7D 33D2                  XOR     DX,DX                   ; WILL SET CURSOR POSITION TO [0,0]
                   ;--------------------------------------------------------------
                   ;       THE LOOP FROM PRI10 TO THE INSTRUCTION PRIOR TO PRI20  :
                   ;       IS THE LOOP TO READ EACH CURSOR POSITION FROM THE      :
                   ;       SCREEN AND PRINT.                                      :
                   ;--------------------------------------------------------------
FF7F               PRI10:
FF7F B402                  MOV     AH,2                    ; TO INDICATE CURSOR SET REQUEST
FF81 CD10                  INT     10H                     ; NEW CURSOR POSITION ESTABLISHED
FF83 B408                  MOV     AH,8                    ; TO INDICATE READ CHARACTER
FF85 CD10                  INT     10H                     ; CHARACTER NOW IN [AL]
FF87 0AC0                  OR      AL,AL                   ; SEE IF VALID CHAR
FF89 7502                  JNZ     PRI15                   ; JUMP IF VALID CHAR
FF8B B020                  MOV     AL,' '                  ; MAKE A BLANK
FF8D               PRI15:
FF8D 52                    PUSH    DX                      ; SAVE CURSOR POSITION
FF8E 33D2                  XOR     DX,DX                   ; INDICATE PRINTER 1
FF90 32E4                  XOR     AH,AH                   ; TO INDICATE PRINT CHAR IN [AL]
FF92 CD17                  INT     17H                     ; PRINT THE CHARACTER
FF94 5A                    POP     DX                      ; RECALL CURSOR POSITION
FF95 F6C425                TEST    AH, 25H                 ; TEST FOR PRINTER ERROR
FF98 7521                  JNZ     ERR10                   ; JUMP IF ERROR DETECTED
FF9A FEC2                  INC     DL                      ; ADVANCE TO NEXT COLUMN
FF9C 3ACA                  CMP     CL,DL                   ; SEE IF AT END OF LINE
FF9E 75DF                  JNZ     PRI10                   ; IF NOT PROCEED
FFA0 32D2                  XOR     DL,DL                   ; BACK TO COLUMN 0
FFA2 8AE2                  MOV     AH,DL                   ; [AH]=0
FFA4 52                    PUSH    DX                      ; SAVE NEW CURSOR POSITION
FFA5 E82300                CALL    CRLF                    ; LINE FEED CARRIAGE RETURN
FFA8 5A                    POP     DX                      ; RECALL CURSOR POSITION
FFA9 FEC6                  INC     DH                      ; ADVANCE TO NEXT LINE
FFAB 3AEE                  CMP     CH,DH                   ; FINISHED?
FFAD 75D0                  JNZ     PRI10                   ; IF NOT CONTINUE
FFAF               PRI20:
FFAF 5A                    POP     DX                      ; RECALL CURSOR POSITION
FFB0 B402                  MOV     AH,2                    ; TO INDICATE CURSOR SET REQUEST
FFB2 CD10                  INT     10H                     ; CURSOR POSITION RESTORED
FFB4 C606000000            MOV     STATUS_BYTE,0           ; INDICATE FINISHED
FFB9 EB0A                  JMP     SHORT EXIT              ; EXIT THE ROUTINE
FFBB               ERR10:
```

Section 5

```
LOC OBJ                 SOURCE

FFBB 5A                          POP     DX                      ; GET CURSOR POSITION
FFBC B402                        MOV     AH,2                    ; TO REQUEST CURSOR SET
FFBE CD10                        INT     10H                     ; CURSOR POSITION RESTORED
FFC0                    ERR20:
FFC0 C6060000FF                  MOV     STATUS_BYTE,0FFH        ; INDICATE ERROR
FFC5                    EXIT:
FFC5 5A                          POP     DX                      ; RESTORE ALL THE REGISTERS USED
FFC6 59                          POP     CX
FFC7 5B                          POP     BX
FFC8 58                          POP     AX
FFC9 1F                          POP     DS
FFCA CF                          IRET
                        PRINT_SCREEN     ENDP

                        ;------ CARRIAGE RETURN, LINE FEED SUBROUTINE

FFCB                    CRLF     PROC    NEAR
FFCB 33D2                        XOR     DX,DX                   ; PRINTER 0
FFCD 32E4                        XOR     AH,AH                   ; WILL NOW SEND INITIAL LF,CR
                                                                 ;  TO PRINTER
FFCF B00A                        MOV     AL,12Q                  ; LF
FFD1 CD17                        INT     17H                     ; SEND THE LINE FEED
FFD3 32E4                        XOR     AH,AH                   ; NOW FOR THE CR
FFD5 B00D                        MOV     AL,15Q                  ; CR
FFD7 CD17                        INT     17H                     ; SEND THE CARRIAGE RETURN
FFD9 C3                          RET
                        CRLF     ENDP

FFDA 50415249545920     D1       DB      'PARITY CHECK 2',13,10
     434845434B2032
FFE8 0D
FFE9 0A
FFEA 363031             F3       DB      '601',13,10
FFED 0D
FFEE 0A

----                    CODE     ENDS

                        ;--------------------------------
                        ;        POWER ON RESET VECTOR   :
                        ;--------------------------------
----                    VECTOR   SEGMENT AT 0FFFFH

                        ;----- POWER ON RESET

0000 EA5BE000F0                  JMP     RESET

0005 31302F32372F38              DB      '10/27/82'              ; RELEASE MARKER
     32
----                    VECTOR   ENDS
                                 END
```

SECTION 6. INSTRUCTION SET

Contents

8088
Register Model

AX:	AH	AL	Accumulator
BX:	BH	BL	Base
CX:	CH	CL	Count
DX:	DH	DL	Data
	SP		Stack Pointer
	BP		Base Pointer
	SI		Source Index
	DI		Destination Index

General Register File

IP		Instruction Pointer
FLAGSH	FLAGSL	Status Flags

CS	Code Segment
DS	Data Segment
SS	Stack Segment
ES	Extra Segment

Segment Register File

Instructions which reference the flag register file as a 16-bit object use the symbol FLAGS to represent the file:

15								7							0
X	X	X	X	OF	DF	IF	TF	SF	ZF	X	AF	X	PF	X	CF

x = Don't Care

AF: Auxiliary Carry - BCD
CF: Carry Flag
PF: Parity Flag
SF: Sign Flag
ZF: Zero Flag

8080 Flags

DF: Direction Flag (Strings)
IF: Interrupt Enable Flag
OF: Overflow Flag (CF $\oplus$ SF)
TF: Trap - Single Step Flag

8088 Flags

Operand Summary

''reg field Bit Assignments:

16-Bit [w = 1]		8-Bit [w = 0]		Segment	
000	AX	000	AL	00	ES
001	CX	001	CL	01	CS
010	DX	010	DL	10	SS
011	BX	011	BL	11	DS
100	SP	100	AH		
101	BP	101	CH		
110	SI	110	DH		
111	DI	111	BH		

Second Instruction Byte Summary

mod	xxx	r/m

mod	Displacement
00	DISP = 0*, disp-low and disp-high are absent
01	DISP = disp-low sign-extended to 16-bits, disp-high is absent
10	DISP = disp-high: disp-low
11	r/m is treated as a ''reg'' field

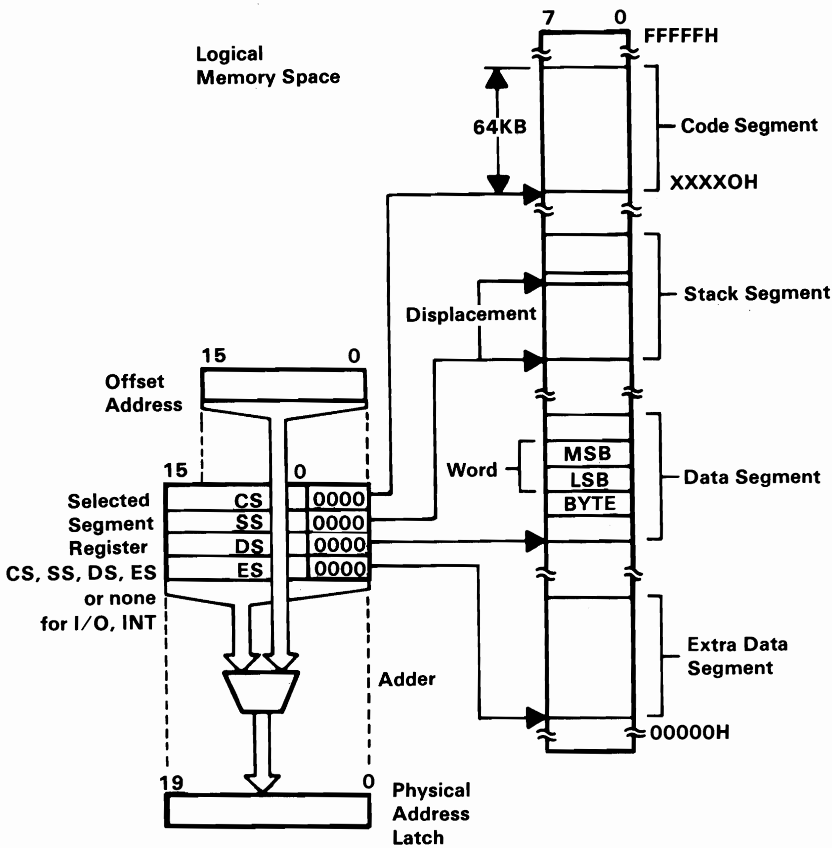
MF = Memory format

00 — 32-bit Real
01 — 32-bit Integer
10 — 64-bit Real
11 — 64-bit Integer

r/m	Operand Address
000	(BX) + (SI) + DISP
001	(BX) + (DI) + DISP
010	(BP) + (SI) + DISP
011	(BP) + (DI) + DISP
100	(SI) + DISP
101	(DI) + DISP
110	(BP) + DISP*
111	(BX) + DISP

DISP follows 2nd byte of instruction (before data if required).
*except if mod = 00 and r/m = 110 then EA = disp-high: disp-low.

Memory Segmentation Model



Segment Override Prefix

0	0	1	reg	1	1	0

Use of Segment Override

Operand Register	Default	With Override Prefix
IP (Code Address)	CS	Never
SP (Stack Address)	SS	Never
BP (Stack Address or Stack Marker)	SS	BP + DS or ES, or CS
SI or DI (not including strings)	DS	ES, SS, or CS
SI (Implicit Source Address for Strings)	DS	ES, SS, or CS
DI (Implicit Destination Address for Strings)	ES	Never

MOV = Move

Register/memory to/from register

1 0 0 0 1 0 d w	mod reg r/m

Immediate to register/memory

1 1 0 0 0 1 1 w	mod 0 0 0 r/m	data	data if w = 1

Immediate to register

1 0 1 1 w reg	data	data if w = 1

Memory to accumulator

1 0 1 0 0 0 0 w	addr-low	addr-high

Accumulator to memory

1 0 1 0 0 0 1 w	addr-low	addr-high

Register/memory to segment register

1 0 0 0 1 1 1 0	mod 0 reg r/m

Segment register to register/memory

1 0 0 0 1 1 0 0	mod 0 reg r/m

PUSH = Push

Register/memory

1 1 1 1 1 1 1 1	mod 1 1 0 r/m

Register

0 1 0 1 0 reg

Segment register

0 0 0 reg 1 1 0

Pop = Pop

Register/memory

1 0 0 0 1 1 1 1	mod 0 0 0 r/m

Register

0 1 0 1 1 reg

Segment register

0 0 0 reg 1 1 1

XCHG = Exchange
Register/memory with register

1 0 0 0 0 1 1 w	mod reg r/m

Register with accumulator

1 0 0 1 0 reg

IN = Input to AL/AX from
Fixed port

1 1 1 0 0 1 0 w	port

Variable port (DX)

1 1 1 0 1 1 0 w

OUT = Output from AL/AX to
Fixed port

1 1 1 0 0 1 1 w	port

Variable port (DX)

1 1 1 0 1 1 0 w

XLAT = Translate byte to AL

1 1 0 1 0 1 1 1

LEA = Load EA to register

1 0 0 0 1 1 0 1	mod reg r/m

LDS = Load pointer to DS

1 1 0 0 0 1 0 1	mod reg r/m

LES = Load pointer to ES

1 1 0 0 0 1 0 0	mod reg r/m

LAHF = Load AH with flags

1 0 0 1 1 1 1 1

SAHF = Store AH into flags

1 0 0 1 1 1 1 0

PUSHF = Push flags

1 0 0 1 1 1 0 0

POPF = Pop flags

1 0 0 1 1 1 0 1

Section 6

Arithmetic

ADD = Add
Register/memory with register to either

0 0 0 0 0 0 d w	mod reg r/m

Immediate to register/memory

1 0 0 0 0 0 s w	mod 0 0 0 r/m	data	data if s:w = 01

Immediate to accumulator

0 0 0 0 0 1 0 w	data	data if w = 1

ADC = Add with carry
Register/memory with register to either

0 0 0 1 0 0 d w	mod reg r/m

Immediate to register/memory

1 0 0 0 0 0 s w	mod 0 1 0 r/m	data	data if s:w = 01

Immediate to accumulator

0 0 0 1 0 1 0 w	data	data if w = 1

INC = Increment
Register/Memory

1 1 1 1 1 1 1 w	mod 0 0 0 r/m

Register

0 1 0 0 0 reg

AAA = ASCII adjust for add

0 0 1 1 0 1 1 1

DAA = Decimal adjust for add

0 0 1 0 0 1 1 1

SUB = Subtract
Register/memory and register to either

0 0 1 0 1 0 d w	mod reg r/m

Immediate from register/memory

1 0 0 0 0 0 s w	mod 1 0 1 r/m	data	data if s:w = 01

Immediate from accumulator

0 0 1 0 1 1 0 w	data	data if w = 1

SBB = Subtract with borrow
Register/memory and register to either

0 0 0 1 1 0 d w	mod reg r/m

Immediate from register/memory

1 0 0 0 0 0 s w	mod 0 1 1 r/m	data	data if s:w = 01

Immediate from accumulator

0 0 0 1 1 1 0 w	data	data if w = 1

DEC = Decrement
Register/memory

1 1 1 1 1 1 1 w	mod 0 0 1 r/m

Register

0 1 0 0 1 reg

NEG = Change sign

1 1 1 1 0 1 1 w	mod 0 1 1 r/m

CMP = Compare
Register/memory and register

0 0 1 1 1 0 d w	mod reg r/m

Immediate with register/memory

1 0 0 0 0 0 s w	mod 1 1 1 r/m	data	data if s:w = 01

Immediate with accumulator

0 0 1 1 1 1 0 w	data	data if w = 1

AAS = ASCII adjust for subtact

0 0 1 1 1 1 1 1

DAS = Decimal adjust for subtact

0 0 1 0 1 1 1 1

MUL = Multiply (unsigned)

1 1 1 1 0 1 1 w	mod 1 0 0 r/m

IMUL = Integer multiply (signed)

1 1 1 1 0 1 1 w	mod 1 0 1 r/m

AAM = ASCII adjust for multiply

1 1 0 1 0 1 0 0	0 0 0 0 1 0 1 0

DIV = Divide (unsigned)

1 1 1 1 0 1 1 w	mod 1 1 0 r/m

IDIV = Integer divide (signed)

1 1 1 1 0 1 1 w	mod 1 1 1 r/m

AAD = ASCII adjust for divide

1 1 0 1 0 1 0 1	0 0 0 0 1 0 1 0

CBW = Convert byte to word

1 0 0 1 1 0 0 0

CWD = Convert word to double word

1 0 0 1 1 0 0 1

Logic

NOT = Invert

1 1 1 1 0 1 1 w	mod 0 1 0 r/m

SHL/SAL = Shift logical/arithmetic left

1 1 0 1 0 0 v w	mod 1 0 0 r/m

SHR = Shift logical right

1 1 0 1 0 0 v w	mod 1 0 1 r/m

SAR = Shift arithmetic right

1 1 0 1 0 0 v w	mod 1 1 1 r/m

ROL = Rotate left

1 1 0 1 0 0 v w	mod 0 0 0 r/m

ROR = Rotate right

1 1 0 1 0 0 v w	mod 0 0 1 r/m

RCL = Rotate through carry left

1 1 0 1 0 0 v w	mod 0 1 0 r/m

RCR = Rotate through carry right

1 1 0 1 0 0 v w	mod 0 1 1 r/m

AND = And
Register/memory and register to either

0 0 1 0 0 0 d w	mod reg r/m

Immediate to register/memory

1 0 0 0 0 0 0 w	mod 1 0 0 r/m	data	data if w = 1

Immediate to accumulator

0 0 1 0 0 1 0 w	data	data if w = 1

TEST = And function to flags, no result
Register/memory and register

1 0 0 0 0 1 0 w	mod reg r/m

Immediate data and register/memory

1 1 1 1 0 1 1 w	mod 0 0 0 r/m	data	data if w = 1

Immediate data and accumulator

1 0 1 0 1 0 0 w	data	data if w = 1

OR = Or
Register/memory and register to either

0 0 0 0 1 0 d w	mod reg r/m

Immediate to register/memory

1 0 0 0 0 0 0 w	mod 0 0 1 r/m	data	data if w = 1

Immediate to accumulator

0 0 0 0 1 1 0 w	data	data if w = 1

XOR = Exclusive or
Register/memory and register to either

0 0 1 1 0 0 d w	mod reg r/m

Immediate to register/memory

1 0 0 0 0 0 0 w	mod 1 1 0 r/m	data	data if w = 1

Immediate to accumulator

0 0 1 1 0 1 0 w	data	data if w = 1

String Manipulation

REP = Repeat

1 1 1 1 0 0 1 z

MOVS = Move String

1 0 1 0 0 1 0 w

CMPS = Compare String

1 0 1 0 0 1 1 w

SCAS = Scan String

1 0 1 0 1 1 1 w

LODS = Load String

1	0	1	0	1	1	0	w

STOS = Store String

1	0	1	0	1	0	1	w

Control Transfer

CALL = Call
Direct within segment

1 1 1 0 1 0 0 0	disp-low	disp-high

Indirect within segment

1 1 1 1 1 1 1 1	mod 0 1 0 r/m

Direct intersegment

1 0 0 1 1 0 1 0	offset-low	offset-high
	seg-low	seg-high

Indirect intersegment

1 1 1 1 1 1 1 1	mod 0 1 1 r/m

JMP = Unconditional Jump
Direct within segment

1 1 1 0 1 0 0 1	disp-low	disp-high

Direct within segment-short

1 1 1 0 1 0 1 1	disp

Indirect within segment

1 1 1 1 1 1 1 1	mod 1 0 0 r/m

Direct intersegment

1 1 1 0 1 0 1 0	offset-low	offset-high
	seg-low	seg-high

Indirect intersegment

1 1 1 1 1 1 1 1	mod 1 0 1 r/m

RET = Return from CALL
Within segment

1	1	0	0	0	0	1	1

Within segment adding immediate to SP

1	1	0	0	0	0	1	0	data-low	data-high

Intersegment

1	1	0	0	1	0	1	1

Intersegment, adding immediate to SP

1	1	0	0	0	0	1	0	data-low	data-high

JE/JZ = Jump on equal/zero

0	1	1	1	0	1	0	0	disp

JL/JNGE = Jump on less/not greater or equal

0	1	1	1	1	1	0	0	disp

JLE/JNG = Jump on less or equal/not greater

0	1	1	1	1	1	1	0	disp

JB/JNAE = Jump on below/not above or equal

0	1	1	1	0	0	1	0	disp

JBE/JNA = Jump on below or equal/not above

0	1	1	1	0	1	1	0	disp

JP/JPE = Jump on parity/parity even

0	1	1	1	1	0	1	0	disp

JO = Jump on overflow

0	1	1	1	0	0	0	0	disp

JS = Jump on sign

0	1	1	1	1	0	0	0	disp

JNE/JNZ = Jump on not equal/not zero

0	1	1	1	0	1	0	1	disp

JNL/JGE = Jump on not less/greater or equal

0	1	1	1	1	1	0	1	disp

JNLE/JG = Jump on not less or equal/greater

0	1	1	1	1	1	1	1	disp

JNB/JAE = Jump on not below/above or equal

0	1	1	1	0	0	1	1	disp

JNBE/JA = Jump on not below or equal/above

0	1	1	1	0	1	1	1	disp

JNP/JPO = Jump on not parity/parity odd

0	1	1	1	1	0	1	1	disp

JNO = Jump on not overflow

0	1	1	1	0	0	0	1	disp

JNS = Jump on not sign

0	1	1	1	1	0	0	1	disp

LOOP = Loop CX times

1	1	1	0	0	0	1	0	disp

LOOPZ/LOOPE = Loop while zero/equal

1	1	1	0	0	0	0	1	disp

LOOPNZ/LOOPNE = Loop while not zero/not equal

1	1	1	0	0	0	0	0	disp

JCXZ = Jump on CX zero

1	1	1	0	0	0	1	1	disp

8088 Conditional Transfer Operations

Instruction	Condition	Interpretation
JE or JZ	ZF = 1	''equal'' or ''zero''
JL or JNGE	(SF xor OF) = 1	''less'' or ''not greater or equal''
JLE or JNG	((SF xor OF) or ZF) = 1	''less or equal'' or ''not greater''
JB or JNAE or JC	CF = 1	''below'' or ''not above or equal''
JBE or JNA	(CF or ZF) = 1	''below or equal'' or ''not above''
JP or JPE	PF = 1	''parity'' or ''parity even''
JO	OF = 1	''overflow''
JS	SF = 1	''sign''
JNE or JNZ	ZF = 0	''not equal'' or ''not zero''
JNL or JGE	(SF xor OF) = 0	''not less'' or ''greater or equal''
JNLE or JG	((SF xor OF) or ZF) = 0	''not less or equal'' or ''greater''
JNB or JAE or JNC	CF = 0	''not below'' or ''above or equal''
JNBE or JA	(CF or ZF) = 0	''not less or equal'' or ''above''
JNP or JPO	PF = 0	''not parity'' or ''parity odd''
JNO	OF = 0	''not overflow''
JNS	SF = 0	''not sign''

*''Above'' and ''below'' refer to the relation between two unsigned values, while ''greater'' and ''less'' refer to the relation between two signed values.

INT = Interrupt
Type specified

1	1	0	0	1	1	0	1	type

Type 3

1	1	0	0	1	1	0	0

INTO = Interrupt on overflow

1	1	0	0	1	1	1	0

IRET = Interrupt return

1	1	0	0	1	1	1	1

Processor Control

CLC = Clear carry

1	1	1	1	1	0	0	0

STC = Set carry

1	1	1	1	1	0	0	1

CMC = Complement carry

1	1	1	1	0	1	0	1

NOP = No operation

1	0	0	1	0	0	0	0

CLD = Clear direction

1	1	1	1	1	1	0	0

STD = Set direction

1	1	1	1	1	1	0	1

CLI = Clear interrupt

1	1	1	1	1	0	1	0

STI = Set interrupt

1	1	1	1	1	0	1	1

HLT = Halt

1	1	1	1	0	1	0	0

WAIT = Wait

1	0	0	1	1	0	1	1

LOCK = Bus lock prefix

1	1	1	1	0	0	0	0

ESC = Escape (to external device)

1 1 0 1 1 x x x	mod x x x r/m

Footnotes:
if d = 1 then "to"; if d = 0 then "from"
if w = 1 then word instruction; if w = 0 then byte instruction
if s:w = 01 then 16 bits of immediate data from the operand
if s:w = 11 then an immediate data byte is signed extended to form the 16-bit operand
if v = 0 then "count" = 1; if v = 1 then "count" in (CL)
x = don't care
z is used for some string primitives to compare with ZF FLAG
AL = 8-bit accumulator
AX = 16-bit accumulator
CX = Count register
DS = Data segment
DX = Variable port register
ES = Extra segment
Above/below refers to unsigned value
Greater = more positive;
Less = less positive (more negative) signed values

Data Transfer

FLD = Load
Integer/Real Memory to ST(0)

Escape MF 1	mod 0 0 0 r/m	disp-low	disp-high

Long Integer Memory to ST(0)

Escape 1 1 1	mod 1 0 1 r/m	disp-low	disp-high

Temporary Real Memory to ST(0)

Escape 0 1 1	mod 1 0 1 r/m	disp-low	disp-high

BCD Memory to ST(0)

Escape 1 1 1	mod 1 0 0 r/m	disp-low	disp-high

ST(i) to ST(0)

Escape 0 0 1	1 1 0 0 0 ST(i)

FST = Store
ST(0) to Integer/Real Memory

Escape MF 1	mod 0 1 0 r/m	disp-low	disp-high

ST(0) to ST(i)

Escape 1 0 1	1 1 0 1 0 ST(i)

FSTP = STORE AND POP

ST(0) to Integer/Real Memory

Escape MF 1	mod 0 1 1 r/m	disp-low	disp-high

ST(0) to Long Integer Memory

Escape 1 1 1	mod 1 1 1 r/m	disp-low	disp-high

ST(0) to Temporary Real Memory

Escape 0 1 1	mod 1 1 1 r/m	disp-low	disp-high

ST(0) to BCD Memory

Escape 1 1 1	mod 1 1 0 r/m	disp-low	disp-high

ST(0) to ST(i)

Escape 1 0 1	1 1 0 1 1 ST(i)

FXCH = Exchange ST(i) and ST(0)

Escape 0 0 1	1 1 0 0 1 ST(i)

Comparison

FCOM = Compare
Integer/Real Memory to ST(0)

Escape MF 0	mod 0 1 0 r/m	disp-low	disp-high

ST(i) to ST(0)

Escape 0 0 0	1 1 0 1 0 ST(i)

FCOMP = Compare and Pop
Integer/Real Memory to ST(0)

Escape MF 0	mod 0 1 1 r/m	disp-low	disp-high

ST(i) to ST(0)

Escape 0 0 0	1 1 0 1 1 ST(i)

FCOMPP = Compare ST(1) to ST(0) and Pop twice

Escape 1 1 0	1 1 0 1 1 0 0 1

FTST = Test ST(0)

Escape 0 0 1	1 1 1 0 0 1 0 0

FXAM = Examine ST(0)

Escape 0 0 1	1 1 1 0 0 1 0 1

Arithmetic

FADD = Addition
Integer/Real Memory with ST(0)

Escape MF 0	mod 0 0 0 r/m	disp-low	disp-high

ST(i) to ST(0)

Escape d P 0	1 1 0 0 0 ST(i)

FSUB = Subtraction
Integer/Real Memory with ST(0)

Escape MF 0	mod 1 0 R r/m	disp-low	disp-high

ST(i) to ST(0)

Escape d P 0	1 1 1 0 R r/m

Arithmetic (Continued)

FMUL = Multiplication
Integer/Real Memory to ST(0)

Escape MF 0	mod 0 0 1 r/m	disp-low	disp-high

ST(i) and ST(0)

Escape d P 0	1 1 0 0 1 r/m

FDIV = Division
Integer/Real Memory with ST(0)

Escape MF 0	mod 1 1 R r/m	disp-low	disp-high

ST(i) and ST(0)

Escape d P 0	1 1 0 0 1 r/m

FSQRT = Square Root of ST(0)

Escape 0 0 1	1 1 1 1 1 0 1 0

FSCALE = Scale ST(0) by ST(1)

Escape 0 0 1	1 1 1 1 1 1 0 1

FPREM = Partial Remainder of ST(0) ÷ ST(1)

Escape 0 0 1	1 1 1 1 1 0 0 0

FRNDINT = Round ST(0) to Integer

Escape 0 0 1	1 1 1 1 1 1 0 0

FXTRACT = Extract Components of ST(0)

Escape 0 0 1	1 1 1 1 0 1 0 0

FABS = Absolute Value of ST(0)

Escape 0 0 1	1 1 1 0 0 0 0 1

FCHS = Change Sign of ST(0)

Escape 0 0 1	1 1 1 0 0 0 0 0

Transcendental

FPTAN = Partial Tangent of ST(0)

Escape	0	0	1	1	1	1	1	0	0	1	0

FPATAN = Partial Arctangent of ST(0) ÷ ST(1)

Escape	0	0	1	1	1	1	1	0	0	1	1

F2XM1 = $2^{ST(0)}-1$

Escape	0	0	1	1	1	1	1	0	0	0	0

FYL2X = $ST(1) \cdot LOG_2[ST(0)]$

Escape	0	0	1	1	1	1	1	0	0	0	1

FYL2XP1 = $ST(1) \cdot LOG_2[ST(0) + 1]$

Escape	0	0	1	1	1	1	1	1	0	0	1

Constants

FLDZ = Load + 0.0 into ST(0)

Escape	0	0	1	1	1	1	0	1	1	1	0

FLD1 = Load + 1.0 into ST(0)

Escape	0	0	1	1	1	1	0	1	0	0	0

FLDPI = Load π into ST(0)

Escape	0	0	1	1	1	1	0	1	0	1	1

FLDL2T = Load $\log_2 10$ into ST(0)

Escape	0	0	1	1	1	1	0	1	0	0	1

FLDL2E = Load $\log_2 e$ into ST(0)

Escape	0	0	1	1	1	1	0	1	0	1	0

FLDLG2 = Load $\log_{10} 2$ into ST(0)

Escape	0	0	1	1	1	1	0	1	1	0	0

FLDLN2 = Load $\log_e 2$ into ST(0)

Escape	0	0	1	1	1	1	0	1	1	0	1

Processor Control

FINIT = Initialize NDP

Escape	0	1	1	1	1	1	0	0	0	1	1

FENI = Enable Interrupts

Escape	0	1	1	1	1	1	0	0	0	0	0

FDISI = Disable Interrupts

Escape	0	1	1	1	1	1	0	0	0	0	1

FLDCW = Load Control Word

Escape	0	0	1	mod	1	0	1	r/m	disp-low	disp-high

FSTCW = Store Control Word

Escape	0	0	1	mod	1	1	1	r/m	disp-low	disp-high

FSTSW = Store Status Word

Escape	1	0	1	mod	1	1	1	r/m	disp-low	disp-high

FCLEX = Clear Exceptions

Escape	0	1	1	1	1	1	0	0	0	1	0

FSTENV = Store Environment

Escape	0	0	1	mod	1	1	0	r/m	disp-low	disp-high

FLDENV = Load Enviroment

Escape 0 0 1	mod 1 0 0 r/m	disp-low	disp-high

FSAVE = Save State

Escape 1 0 1	mod 1 1 0 r/m	disp-low	disp-high

FRSTOR = Restore State

Escape 1 0 1	mod 1 0 0 r/m	disp-low	disp-high

FINCSTP = Increment Stack Pointer

Escape 0 0 1	1 1 1 1 0 1 1 1

FDECSTP = Decrement Stack Pointer

Escape 0 0 1	1 1 1 1 0 1 1 0

FFREE = Free ST(i)

Escape 0 0 1	1 1 0 0 0 ST(i)

FNOP = No Operation

Escape 0 0 1	1 1 0 1 0 0 0 0

FWAIT = CPU Wait for NDP

1 0 0 1 1 0 1 1

Footnotes:

ST(0) = Current Stack top

ST(i) = i^{th} register below stack top

d = Destination

0 — Destination is ST(0)

1 — Destination is ST(i)

P = POP

0 — No pop

1 — Pop ST(0)

R = Reverse

0 — Destination (op) Source

1 — Source (op) Destination

For **FSQRT:** $-0 \leq ST(0) \leq +\infty$

For **FSCALE:** $-2^{15} \leq ST(1) < +2^{15}$ and ST(1) integer

For **F2XM1:** $0 \leq ST(0) \leq 2^{-1}$

For **FYL2X:** $0 < ST(0) < \infty$

$-\infty < ST(1) < +\infty$

For **FYL2XP1:** $0 < |ST(0)| < (2 - \sqrt{2})/2$

$-\infty < ST(1) < \infty$

For **FPTAN:** $0 \leq ST(0) < \pi/4$

For **FPATAN:** $0 \leq ST(0) < ST(1) < +\infty$

8088 Instruction Set Matrix

HI \ LO	0	1	2	3	4	5	6	7
0	ADD b,f,r/m	ADD w,f,r/m	ADD b,t,r/m	ADD w,t,r/m	ADD b,ia	ADD w,ia	PUSH ES	POP ES
1	ADC b,f,r/m	ADC w,f,r/m	ADC b,t,r/m	ADC w,t,r/m	ADC b,i	ADC w,i	PUSH SS	POP SS
2	AND b,f,r/m	AND w,f,r/m	AND b,t,r/m	AND w,t,r/m	AND b,i	AND w,i	SEG =ES	DAA
3	XOR b,f,r/m	XOR w,f,r/m	XOR b,t,r/m	XOR w,t,r/m	XOR b,i	XOR w,i	SEG =SS	AAA
4	INC AX	INC CX	INC DX	INC BX	INC SP	INC BP	INC SI	INC DI
5	PUSH AX	PUSH CX	PUSH DX	PUSH BX	PUSH SP	PUSH BP	PUSH SI	PUSH D1
6								
7	JO	JNO	JB/ JNAE	JNB/ JAE	JE/ JZ	JNE/ JNZ	JBE/ JNA	JNBE/ JA
8	Immed b,r/m	Immed w,r/m	Immed b,r/m	Immed is,r/m	TEST b,r/m	TEST w,r/m	XCHG b,r/m	XCHG w,r/m
9	NOP	XCHG CX	XCHG DX	XCHG BX	XCHG SP	XCHG BP	XCHG SI	XCHG DI
A	MOV m AL	MOV m AL	MOV AL m	MOV AL m	MOVS b	MOVS w	CMPS b	CMPS w
B	MOV i AL	MOV i CL	MOV i DL	MOV i BL	MOV i AH	MOV i CH	MOV i DH	MOV i BH
C			RET (i+SP)	RET	LES	LDS	MOV b,i,r/m	MOV w,i,r/m
D	Shift b	Shift w	Shift b,v	Shift w,v	AAM	AAD		XLAT
E	LOOPNZ/ LOOPNE	LOOPZ/ LOOPE	LOOP	JCXZ	IN b	IN w	OUT b	OUT w
F	LOCK		REP	REP z	HLT	CMC	Grp 1 b,r/m	Grp 1 w,r/m

b = byte operation
d = direct
f = from CPU reg
i = immediate
ia = immed. to accum.
id = indirect
is = immed. byte, sign ext.
l = long ie. intersegment

m = memory
r/m = EA is second byte
si = short intrasegment
sr = segment register
t = to CPU reg
v = variable
w = word operation
z = zero

8088 Instruction Set Matrix

HI \ LO	8	9	A	B	C	D	E	F
0	OR b,f,r/m	w,f,r/m	OR b,t,r/m	OR w,t,r/m	OR b,i	OR w,i	PUSH CS	
1	SBB b,f,r/m	SBB w,f,r/m	SBB b,t,r/m	SBB w,t,r/m	SBB b,i	SBB w,i	PUSH DS	POP DS
2	SUB b,f,r/m	SUB w,f,r/m	SUB b,t,r/m	SUB w,t,r/m	SUB b,i	SUB w,i	SEG= CS	DAS
3	CMP b,f,r/m	CMP w,f,r/m	CMP b,t,r/m	CMP w,t,r/m	CMP b,i	CMP w,i	SEG= CS	AAS
4	DEC AX	DEC CX	DEC DX	DEC BX	DEC SP	DEC BP	DEC SI	DEC DI
5	POP AX	POP CX	POP DX	POP BX	POP SP	POP BP	POP SI	POP DI
6								
7	JS	JNS	JP/ JPE	JNP/ JPO	JL/ JNGE	JNL/ JGE	JLE/ JNG	JNLE/ JG
8	MOV b,f,r/m	MOV w,f,r/m	MOV b,t,r/m	MOV w,t,r/m	MOV sr,t,r/m	LEA	MOV sr,f,r/m	POP r/m
9	CBW	CWD	CALL l,d	WAIT	PUSHF	POPF	SAHF	LAHF
A	TEST b,i	TEST w,i	STOS b	STOS w	LODS b	LODS w	SCAS b	SCAS w
B	MOV i AX	MOV i CX	MOV i DX	MOV i BX	MOV i SP	MOV i BP	MOV i SI	MOV i DI
C			RET l,(i+SP)	RET l	INT Type 3	INT (Any)	INTO	IRET
D	ESC 0	ESC 1	ESC 2	ESC 3	ESC 4	ESC 5	ESC 6	ESC 7
E	CALL d	JMP d	JMP l,d	JMP si,d	IN v,b	IN v,w	OUT v,b	OUT v,w
F	CLC	STC	CLI	STI	CLD	STD	Grp 2 b,r/m	Grp 2 w,r/m

where:

mod r/m	000	001	010	011	100	101	110	111
Immed	ADD	OR	ADC	SBB	AND	SUB	XOR	CMP
Shift	ROL	ROR	RCL	RCR	SHL/SAL	SHR	—	SAR
Grp 1	TEST	—	NOT	NEG	MUL	IMUL	DIV	IDIV
Grp 2	INC	DEC	CALL id	CALL l,id	JMP id	JMP l,id	PUSH	—

Instruction Set Index

Notes:

SECTION 7. CHARACTERS, KEYSTROKES, AND COLORS

Value		As Characters			As Text Attributes		
					Color/Graphics Monitor Adapter		IBM Monochrome Display Adapter
Hex	Dec	Symbol	Keystrokes	Modes	Background	Foreground	
00	0	Blank (Null)	Ctrl 2		Black	Black	Non-Display
01	1	☺	Ctrl A		Black	Blue	Underline
02	2	☻	Ctrl B		Black	Green	Normal
03	3	♥	Ctrl C		Black	Cyan	Normal
04	4	♦	Ctrl D		Black	Red	Normal
05	5	♣	Ctrl E		Black	Magenta	Normal
06	6	♠	Ctrl F		Black	Brown	Normal
07	7	•	Ctrl G		Black	Light Grey	Normal
08	8	◘	Ctrl H, Backspace, Shift Backspace		Black	Dark Grey	Non-Display
09	9	○	Ctrl I		Black	Light Blue	High Intensity Underline
0A	10	◙	Ctrl J, Ctrl ↵		Black	Light Green	High Intensity
0B	11	♂	Ctrl K		Black	Light Green	High Intensity
0C	12	♀	Ctrl L,		Black	Light Red	High Intensity
0D	13	♪	Ctrl M, ↵, Shift ↵		Black	Light Magenta	High Intensity
0E	14	♫	Ctrl N		Black	Yellow	High Intensity
0F	15	☼	Ctrl O		Black	White	High Intensity
10	16	►	Ctrl P		Blue	Black	Normal
11	17	◄	Ctrl Q		Blue	Blue	Underline
12	18	↕	Ctrl R		Blue	Green	Normal
13	19	‼	Ctrl S		Blue	Cyan	Normal
14	20	¶	Ctrl T		Blue	Red	Normal
15	21	§	Ctrl U			Magenta	Normal
16	22	▬	Ctrl V		Blue	Brown	Normal
17	23	↨	Ctrl W		Blue	Light Grey	Normal

Value		As Characters			As Text Attributes		
					Color/Graphics Monitor Adapter		IBM Monochrome Display Adapter
Hex	Dec	Symbol	Keystrokes	Modes	Background	Foreground	
18	24	↑	Ctrl X		Blue	Dark Grey	High Intensity
19	25	↓	Ctrl Y		Blue	Light Blue	High Intensity Underline
1A	26	→	Ctrl Z		Blue	Light Green	High Intensity
1B	27	←	Ctrl [, Esc, Shift Esc, Ctrl Esc		Blue	Light Cyan	High Intensity
1C	28	∟	Ctrl \		Blue	Light Red	High Intensity
1D	29	↔	Ctrl]		Blue	Light Magenta	High Intensity
1E	30	▲	Ctrl 6		Blue	Yellow	High Intensity
1F	31	▼	Ctrl –		Blue	White	High Intensity
20	32	Blank Space	Space Bar, Shift, Space, Ctrl Space, Alt Space		Green	Black	Normal
21	33	!	!	Shift	Green	Blue	Underline
22	34	"	"	Shift	Green	Green	Normal
23	35	#	#	Shift	Green	Cyan	Normal
24	36	$	$	Shift	Green	Red	Normal
25	37	%	%	Shift	Green	Magenta	Normal
26	38	&	&	Shift	Green	Brown	Normal
27	39	'	'		Green	Light Grey	Normal
28	40	(	(	Shift	Green	Dark Grey	High Intensity
29	41	)	)	Shift	Green	Light Blue	High Intensity Underline
2A	42	*	*	Note 1	Green	Light Green	High Intensity
28	43	+	+	Shift	Green	Light Cyan	High Intensity
2C	44	,	,		Green	Light Red	High Intensity
2D	45	—	—		Green	Light Magenta	High Intensity
2E	46	.	.	Note 2	Green	Yellow	High Intensity

Value		As Characters			As Text Attributes		
					Color/Graphics Monitor Adapter		IBM Monochrome Display Adapter
Hex	Dec	Symbol	Keystrokes	Modes	Background	Foreground	
2F	47	/	/		Green	White	High Intensity
30	48	0	0	Note 3	Cyan	Black	Normal
31	49	1	1	Note 3	Cyan	Blue	Underline
32	50	2	2	Note 3	Cyan	Green	Normal
33	51	3	3	Note 3	Cyan	Cyan	Normal
34	52	4	4	Note 3	Cyan	Red	Normal
35	53	5	5	Note 3	Cyan	Magenta	Normal
36	54	6	6	Note 3	Cyan	Brown	Normal
37	55	7	7	Note 3	Cyan	Light Grey	Normal
38	56	8	8	Note 3	Cyan	Dark Grey	High Intensity
39	57	9	9	Note 3	Cyan	Light Blue	High Intensity Underline
3A	58	:	:	Shift	Cyan	Light Green	High Intensity
3B	59	;	;		Cyan	Light Cyan	High Intensity
3C	60	<	<	Shift	Cyan	Light Red	High Intensity
3D	61	=	=		Cyan	Light Magenta	High Intensity
3E	62	>	>	Shift	Cyan	Yellow	High Intensity
3F	63	?	?	Shift	Cyan	White	High Intensity
40	64	@	@	Shift	Red	Black	Normal
41	65	A	A	Note 4	Red	Blue	Underline
42	66	B	B	Note 4	Red	Green	Normal
43	67	C	C	Note 4	Red	Cyan	Normal
44	68	D	D	Note 4	Red	Red	Normal
45	69	E	E	Note 4	Red	Magenta	Normal
46	70	F	F	Note 4	Red	Brown	Normal
47	71	G	G	Note 4	Red	Light Grey	Normal
48	72	H	H	Note 4	Red	Dark Grey	High Intensity
49	73	I	I	Note 4	Red	Light Blue	High Intensity Underline
4A	74	J	J	Note 4	Red	Light Green	High Intensity

Value		As Characters			As Text Attributes		
					Color/Graphics Monitor Adapter		IBM Monochrome Display Adapter
Hex	Dec	Symbol	Keystrokes	Modes	Background	Foreground	
4B	75	K	K	Note 4	Red	Light Cyan	High Intensity
4C	76	L	L	Note 4	Red	Light Red	High Intensity
4D	77	M	M	Note 4	Red	Light Magenta	High Intensity
4E	78	N	N	Note 4	Red	Yellow	High Intensity
4F	79	O	O	Note 4	Red	White	High Intensity
50	80	P	P	Note 4	Magenta	Black	Normal
51	81	Q	Q	Note 4	Magenta	Blue	Underline
52	82	R	R	Note 4	Magenta	Green	Normal
53	83	S	S	Note 4	Magenta	Cyan	Normal
54	84	T	T	Note 4	Magenta	Red	Normal
55	85	U	U	Note 4	Magenta	Magenta	Normal
56	86	V	V	Note 4	Magenta	Brown	Normal
57	87	W	W	Note 4	Magenta	Light Grey	Normal
58	88	X	X	Note 4	Magenta	Dark Grey	High Intensity
59	89	Y	Y	Note 4	Magenta	Light Blue	High Intensity Underline
5A	90	Z	Z	Note 4	Magenta	Light Green	High Intensity
5B	91	[	[		Magenta	Light Cyan	High Intensity
5C	92	\	\		Magenta	Light Red	High Intensity
5D	93	]	]		Magenta	Light Magenta	High Intensity
5E	94	^	^	Shift	Magenta	Yellow	High Intensity
5F	95	—	—	Shift	Magenta	White	High Intensity
60	96	'	'		Yellow	Black	Normal
61	97	a	a	Note 5	Yellow	Blue	Underline
62	98	b	b	Note 5	Yellow	Green	Normal
63	99	c	c	Note 5	Yellow	Cyan	Normal
64	100	d	d	Note 5	Yellow	Red	Normal
65	101	e	e	Note 5	Yellow	Magenta	Normal
66	102	f	f	Note 5	Yellow	Brown	Normal

Value		As Characters			As Text Attributes		
					Color/Graphics Monitor Adapter		IBM Monochrome Display Adapter
Hex	Dec	Symbol	Keystrokes	Modes	Background	Foreground	
67	103	g	g	Note 5	Yellow	Light Grey	Normal
68	104	h	h	Note 5	Yellow	Dark Grey	High Intensity
69	105	i	i	Note 5	Yellow	Light Blue	High Intensity Underline
6A	106	j	j	Note 5	Yellow	Light Green	High Intensity
6B	107	k	k	Note 5	Yellow	Light Cyan	High Intensity
6C	108	l	l	Note 5	Yellow	Light Red	High Intensity
6D	109	m	m	Note 5	Yellow	Light Magenta	High Intensity
6E	110	n	n	Note 5	Yellow	Yellow	High Intensity
6F	111	o	o	Note 5	Yellow	White	High Intensity
70	112	p	p	Note 5	White	Black	Reverse Video
71	113	q	q	Note 5	White	Blue	Underline
72	114	r	r	Note 5	White	Green	Normal
73	115	s	s	Note 5	White	Cyan	Normal
74	116	f	f	Note 5	White	Red	Normal
75	117	u	u	Note 5	White	Magenta	Normal
76	118	v	v	Note 5	White	Brown	Normal
77	119	w	w	Note 5	White	Light Grey	Normal
78	120	x	x	Note 5	White	Dark Grey	Reverse Video
79	121	y	y	Note 5	White	Light Blue	High Intensity Underline
7A	122	z	z	Note 5	White	Light Green	High Intensity
7B	123	{	{	Shift	White	Light Cyan	High Intensity
7C	124	¦	¦	Shift	White	Light Red	High Intensity
7D	125	}	}	Shift	White	Light Magenta	High Intensity
7E	126	~	~	Shift	White	Yellow	High Intensity
7F	127	Δ	Ctrl ←		White	White	High Intensity

Value		As Characters			As Text Attributes		
					Color/Graphics Monitor Adapter		IBM Monochrome Display Adapter
Hex	Dec	Symbol	Keystrokes	Modes	Background	Foreground	
* * * *		80 to FF Hex are Flashing in both Color & IBM Monochrome * * * *					
80	128	Ç	Alt 128	Note 6	Black	Black	Non-Display
81	129	ü	Alt 129	Note 6	Black	Blue	Underline
82	130	é	Alt 130	Note 6	Black	Green	Normal
83	131	â	Alt 131	Note 6	Black	Cyan	Normal
84	132	ä	Alt 132	Note 6	Black	Red	Normal
85	133	à	Alt 133	Note 6	Black	Magenta	Normal
86	134	å	Alt 134	Note 6	Black	Brown	Normal
87	135	ç	Alt 135	Note 6	Black	Light Grey	Normal
88	136	ê	Alt 136	Note 6	Black	Dark Grey	Non-Display
89	137	ë	Alt 137	Note 6	Black	Light Blue	High Intensity Underline
8A	138	è	Alt 138	Note 6	Black	Light Green	High Intensity
8B	139	ï	Alt 139	Note 6	Black	Light Cyan	High Intensity
8C	140	î	Alt 140	Note 6	Black	Light Red	High Intensity
8D	141	ì	Alt 141	Note 6	Black	Light Magenta	High Intensity
8E	142	Ä	Alt 142	Note 6	Black	Yellow	High Intensity
8F	143	Å	Alt 143	Note 6	Black	White	High Intensity
90	144	É	Alt 144	Note 6	Blue	Black	Normal
91	145	æ	Alt 145	Note 6	Blue	Blue	Underline
92	146	Æ	Alt 146	Note 6	Blue	Green	Normal
93	147	ô	Alt 147	Note 6	Blue	Cyan	Normal
94	148	ö	Alt 148	Note 6	Blue	Red	Normal
95	149	ò	Alt 149	Note 6	Blue	Magenta	Normal
96	150	û	Alt 150	Note 6	Blue	Brown	Normal
97	151	ù	Alt 151	Note 6	Blue	Light Grey	Normal
98	152	ÿ	Alt 152	Note 6	Blue	Dark Grey	High Intensity
99	153	Ö	Alt 153	Note 6	Blue	Light Blue	High Intensity Underline
9A	154	Ü	Alt 154	Note 6	Blue	Light Green	High Intensity

Value		As Characters			As Text Attributes		
					Color/Graphics Monitor Adapter		IBM Monochrome Display Adapter
Hex	Dec	Symbol	Keystrokes	Modes	Background	Foreground	
9B	155	¢	Alt 155	Note 6	Blue	Light Cyan	High Intensity
9C	156	£	Alt 156	Note 6	Blue	Light Red	High Intensity
9D	157	¥	Alt 157	Note 6	Blue	Light Magenta	High Intensity
9E	158	Pt	Alt 158	Note 6	Blue	Yellow	High Intensity
9F	159	ƒ	Alt 159	Note 6	Blue	White	High Intensity
A0	160	á	Alt 160	Note 6	Green	Black	Normal
A1	161	í	Alt 161	Note 6	Green	Blue	Underline
A2	162	ó	Alt 162	Note 6	Green	Green	Normal
A3	163	ú	Alt 163	Note 6	Green	Cyan	Normal
A4	164	ñ	Alt 164	Note 6	Green	Red	Normal
A5	165	Ñ	Alt 165	Note 6	Green	Magenta	Normal
A6	166	ª	Alt 166	Note 6	Green	Brown	Normal
A7	167	º	Alt 167	Note 6	Green	Light Grey	Normal
A8	168	¿	Alt 168	Note 6	Green	Dark Grey	High Intensity
A9	169	⌐	Alt 169	Note 6	Green	Light Blue	High Intensity Underline
AA	170	¬	Alt 170	Note 6	Green	Light Green	High Intensity
AB	171	½	Alt 171	Note 6	Green	Light Cyan	High Intensity
AC	172	¼	Alt 172	Note 6	Green	Light Red	High Intensity
AD	173	¡	Alt 173	Note 6	Green	Light Magenta	High Intensity
AE	174	<<	Alt 174	Note 6	Green	Yellow	High Intensity
AF	175	>>	Alt 175	Note 6	Green	White	High Intensity
B0	176	░	Alt 176	Note 6	Cyan	Black	Normal
B1	177	▒	Alt 177	Note 6	Cyan	Blue	Underline
B2	178	▓	Alt 178	Note 6	Cyan	Green	Normal
B3	179	│	Alt 179	Note 6	Cyan	Cyan	Normal
B4	180	┤	Alt 180	Note 6	Cyan	Red	Normal
B5	181	╡	Alt 181	Note 6	Cyan	Magenta	Normal
B6	182	╢	Alt 182	Note 6	Cyan	Brown	Normal

Value		As Characters			As Text Attributes		
					Color/Graphics Monitor Adapter		IBM Monochrome Display Adapter
Hex	Dec	Symbol	Keystrokes	Modes	Background	Foreground	
B7	183	╖	Alt 183	Note 6	Cyan	Light Grey	Normal
B8	184	╕	Alt 184	Note 6	Cyan	Dark Grey	High Intensity
B9	185	╣	Alt 185	Note 6	Cyan	Light Blue	High Intensity Underline
BA	186	║	Alt 186	Note 6	Cyan	Light Green	High Intensity
BB	187	╗	Alt 187	Note 6	Cyan	Light Cyan	High Intensity
BC	188	╝	Alt 188	Note 6	Cyan	Light Red	High Intensity
BD	189	╜	Alt 189	Note 6	Cyan	Light Magenta	High Intensity
BE	190	╛	Alt 190	Note 6	Cyan	Yellow	High Intensity
BF	191	┐	Alt 191	Note 6	Cyan	White	High Intensity
C0	192	└	Alt 192	Note 6	Red	Black	Normal
C1	193	┴	Alt 193	Note 6	Red	Blue	Underline
C2	194	┬	Alt 194	Note 6	Red	Green	Normal
C3	195	├	Alt 195	Note 6	Red	Cyan	Normal
C4	196	─	Alt 196	Note 6	Red	Red	Normal
C5	197	┼	Alt 197	Note 6	Red	Magenta	Normal
C6	198	╞	Alt 198	Note 6	Red	Brown	Normal
C7	199	╟	Alt 199	Note 6	Red	Light Grey	Normal
C8	200	╚	Alt 200	Note 6	Red	Dark Grey	High Intensity
C9	201	╔	Alt 201	Note 6	Red	Light Blue	High Intensity Underline
CA	202	╩	Alt 202	Note 6	Red	Light Green	High Intensity
CB	203	╦	Alt 203	Note 6	Red	Light Cyan	High Intensity
CC	204	╠	Alt 204	Note 6	Red	Light Red	High Intensity
CD	205	═	Alt 205	Note 6	Red	Light Magenta	High Intensity
CE	206	╬	Alt 206	Note 6	Red	Yellow	High Intensity
CF	207	╧	Alt 207	Note 6	Red	White	High Intensity
D0	208	╨	Alt 208	Note 6	Magenta	Black	Normal

Value		As Characters			As Text Attributes		
					Color/Graphics Monitor Adapter		IBM Monochrome Display Adapter
Hex	Dec	Symbol	Keystrokes	Modes	Background	Foreground	
D1	209	╤	Alt 209	Note 6	Magenta	Blue	Underline
D2	210	╥	Alt 210	Note 6	Magenta	Green	Normal
D3	211	╙	Alt 211	Note 6	Magenta	Cyan	Normal
D4	212	╘	Alt 212	Note 6	Magenta	Red	Normal
D5	213	╒	Alt 213	Note 6	Magenta	Magenta	Normal
D6	214	╓	Alt 214	Note 6	Magenta	Brown	Normal
D7	215	╫	Alt 215	Note 6	Magenta	Light Grey	Normal
D8	216	╪	Alt 216	Note 6	Magenta	Dark Grey	High Intensity
D9	217	┘	Alt 217	Note 6	Magenta	Light Blue	High Intensity Underline
DA	218	┌	Alt 218	Note 6	Magenta	Light Green	High Intensity
DB	219	█	Alt 219	Note 6	Magenta	Light Cyan	High Intensity
DC	220	▄	Alt 220	Note 6	Magenta	Light Red	High Intensity
DD	221	▌	Alt 221	Note 6	Magenta	Light Magenta	High Intensity
DE	222	▐	Alt 222	Note 6	Magenta	Yellow	High Intensity
DF	223	▀	Alt 223	Note 6	Magenta	White	High Intensity
E0	224	α	Alt 224	Note 6	Yellow	Black	Normal
E1	225	β	Alt 225	Note 6	Yellow	Blue	Underline
E2	226	Γ	Alt 226	Note 6	Yellow	Green	Normal
E3	227	π	Alt 227	Note 6	Yellow	Cyan	Normal
E4	228	Σ	Alt 228	Note 6	Yellow	Red	Normal
E5	229	σ	Alt 229	Note 6	Yellow	Magenta	Normal
E6	230	μ	Alt 230	Note 6	Yellow	Brown	Normal
E7	231	τ	Alt 231	Note 6	Yellow	Light Grey	Normal
E8	232	Φ	Alt 232	Note 6	Yellow	Dark Grey	High Intensity
E9	233	θ	Alt 233	Note 6	Yellow	Light Blue	High Intensity Underline
EA	234	Ω	Alt 234	Note 6	Yellow	Light Green	High Intensity
EB	235	δ	Alt 235	Note 6	Yellow	Light Cyan	High Intensity

Value		As Characters			As Text Attributes		
					Color/Graphics Monitor Adapter		IBM Monochrome Display Adapter
Hex	Dec	Symbol	Keystrokes	Modes	Background	Foreground	
EC	236	∞	Alt 236	Note 6	Yellow	Light Red	High Intensity
ED	237	φ	Alt 237	Note 6	Yellow	Light Magenta	High Intensity
EE	238	ε	Alt 238	Note 6	Yellow	Yellow	High Intensity
EF	239	∩	Alt 239	Note 6	Yellow	White	High Intensity
F0	240	≡	Alt 240	Note 6	White	Black	Reverse Video
F1	241	±	Alt 241	Note 6	White	Blue	Underline
F2	242	≥	Alt 242	Note 6	White	Green	Normal
F3	243	≤	Alt 243	Note 6	White	Cyan	Normal
F4	244	⌠	Alt 244	Note 6	White	Red	Normal
F5	245	⌡	Alt 245	Note 6	White	Magenta	Normal
F6	246	÷	Alt 246	Note 6	White	Brown	Normal
F7	247	≈	Alt 247	Note 6	White	Light Grey	Normal
F8	248	°	Alt 248	Note 6	White	Dark Grey	Reverse Video
F9	249	●	Alt 249	Note 6	White	Light Blue	High Intensity Underline
FA	250	•	Alt 250	Note 6	White	Light Green	High Intensity
FB	251	√	Alt 251	Note 6	White	Light Cyan	High Intensity
FC	252	η	Alt 252	Note 6	White	Light Red	High Intensity
FD	253	²	Alt 253	Note 6	White	Light Magenta	High Intensity
FE	254	■	Alt 254	Note 6	White	Yellow	High Intensity
FF	255	**BLANK**	Alt 255	Note 6	White	White	High Intensity

NOTE 1 Asterisk (*) can easily be keyed using two methods: 1) hit the Prt Sc * key or 2) in shift mode hit the * 8 key.

NOTE 2 Period (.) can easily be keyed using two methods: 1) hit the > . key or 2) in shift or Num Lock mode hit the . Del key.

NOTE 3 Numeric characters (0—9) can easily be keyed using two methods: 1) hit the numeric keys on the top row of the typewriter portion of the keyboard or 2) in shift or Num Lock mode hit the numeric keys in the 10—key pad portion of the keyboard.

NOTE 4 Upper case alphabetic characters (A—Z) can easily be keyed in two modes: 1) in shift mode the appropriate alphabetic key or 2) in Caps Lock mode hit the appropriate alphabetic key.

NOTE 5 Lower case alphabetic characters (a—z) can easily be keyed in two modes: 1) in "normal" mode hit the appropriate key or 2) in Caps Lock combined with shift mode hit the appropriate alphabetic key.

NOTE 6 The 3 digits after the Alt key must be typed from the numeric key pad (keys 71—73, 75—77, 79—82). Character codes 000 through 255 can be entered in this fashion. (With Caps Lock activated, Character codes 97 through 122 will display upper case rather than lower case alphabetic characters.)

Character Set (00-7F) Quick Reference

DECIMAL VALUE	➡	0	16	32	48	64	80	96	112
⬇	HEXA DECIMAL VALUE	0	1	2	3	4	5	6	7
0	0	BLANK (NULL)	►	BLANK (SPACE)	0	@	P	‘	p
1	1	☺	◄	!	1	A	Q	a	q
2	2	☻	↕	"	2	B	R	b	r
3	3	♥	‼	#	3	C	S	c	s
4	4	♦	¶	$	4	D	T	d	t
5	5	♣	§	%	5	E	U	e	u
6	6	♠	▬	&	6	F	V	f	v
7	7	•	↨	'	7	G	W	g	w
8	8	◘	↑	(	8	H	X	h	x
9	9	○	↓	)	9	I	Y	i	y
10	A	◙	→	*	:	J	Z	j	z
11	B	♂	←	+	;	K	[	k	{
12	C	♀	∟	,	<	L	\	l	¦
13	D	♪	↔	—	=	M	]	m	}
14	E	♫	▲	.	>	N	^	n	~
15	F	☼	▼	/	?	O	_	o	⌂

Character Set (80-FF) Quick Reference

DECIMAL VALUE	➡	128	144	160	176	192	208	224	240
⬇	HEXA DECIMAL VALUE	8	9	A	B	C	D	E	F
0	0	Ç	É	á	░	└	╨	α	≡
1	1	ü	æ	í	▒	┴	╤	β	±
2	2	é	Æ	ó	▓	┬	╥	Γ	≥
3	3	â	ô	ú	│	├	╙	π	≤
4	4	ä	ö	ñ	┤	─	╘	Σ	⌠
5	5	à	ò	Ñ	╡	┼	╒	σ	⌡
6	6	å	û	ª	╢	╞	╓	µ	÷
7	7	ç	ù	º	╖	╟	╫	τ	≈
8	8	ê	ÿ	¿	╕	╚	╪	Φ	°
9	9	ë	Ö	⌐	╣	╔	┘	Θ	•
10	A	è	Ü	¬	║	╩	┌	Ω	·
11	B	ï	¢	½	╗	╦	█	δ	√
12	C	î	£	¼	╝	╠	▄	∞	n
13	D	ì	¥	¡	╜	═	▌	φ	2
14	E	Ä	₧	«	╛	╬	▐	∈	■
15	F	Å	ƒ	»	┐	╧	▀	∩	BLANK 'FF'

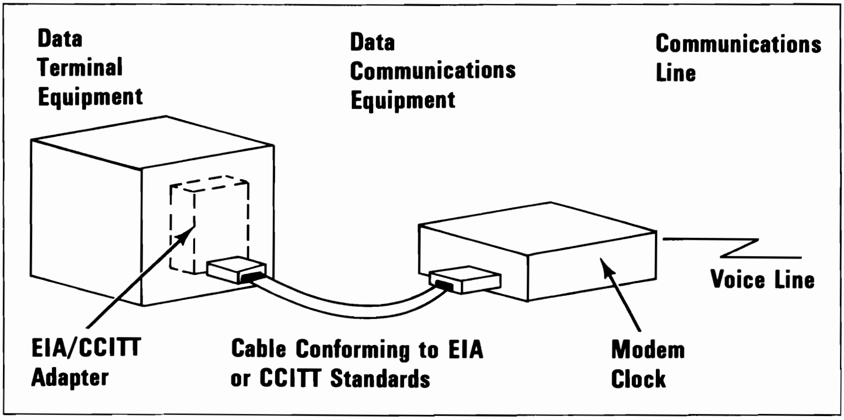
Notes:

SECTION 8. COMMUNICATIONS

Contents

Information processing equipment used for communications is called data terminal equipment (DTE). Equipment used to connect the DTE to the communications line is called data communications equipment (DCE).

An adapter is used to connect the data terminal equipment to the data communications line as shown in the following illustration:



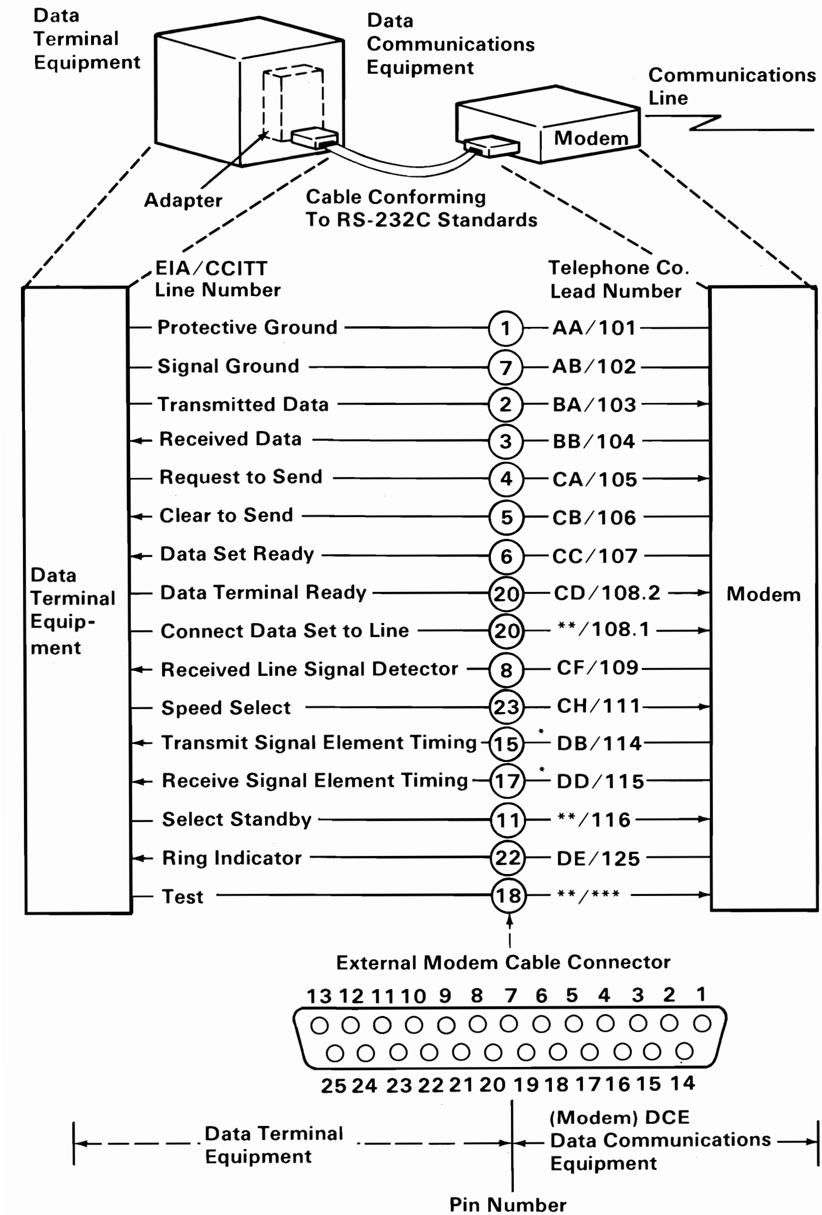
The EIA/ CCITT adapter allows data terminal equipment to be connected to data communications equipment using EIA or CCITT standardized connections. An external modem is shown in this example; however, other types of data communications equipment can also be connected to data terminal equipment using EIA or CCITT standardized connections.

EIA standards are labeled RS-x (Recommended Standards-x) and CCITT standards are labeled V.x or X.x, where x is the number of the standard.

The EIA RS-232 interface standard defines the connector type, pin numbers, line names, and signal levels used to connect data terminal equipment to data communications equipment for the purpose of transmitting and receiving data. Since the RS-232 standard was developed, it has been revised three times. The three revised standards are the RS-232A, the RS-232B, and the presently used RS-232C.

The CCITT V.24 interface standard is equivalent to the RS-232C standard; therefore, the descriptions of the EIA standards also apply to the CCITT standards.

The following is an illustration of data terminal equipment connected to an external modem using connections defined by the RS-232C interface standard:



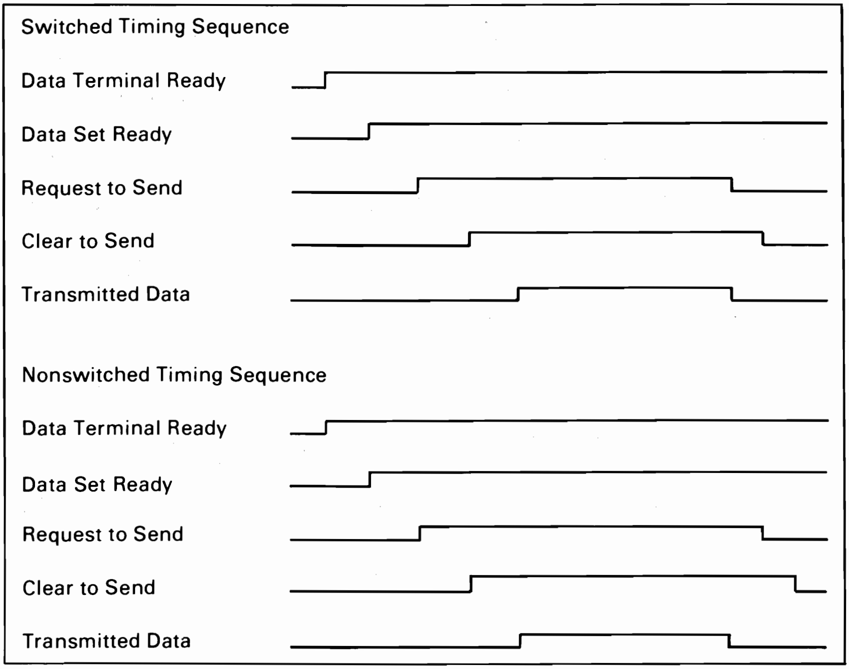
*Not used when business machine clocking is used.

**Not standardized by EIA (Electronic Industries Association).

***Not standardized by CCITT

Establishing a Communications Link

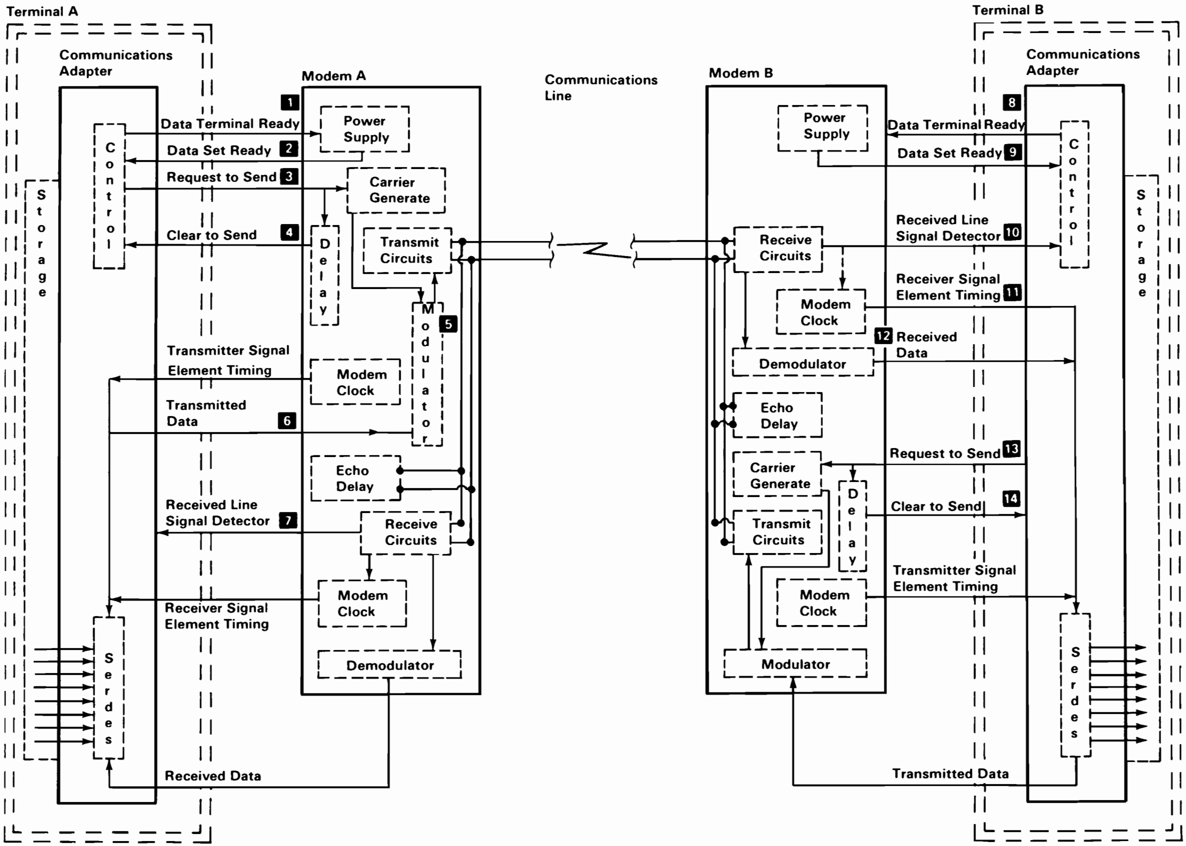
The following bar graphs represent normal timing sequences of operation during the establishment of communications for both switched (dial-up) and nonswitched (direct line) networks.



The following examples show how a link is established on a nonswitched point-to-point line, a nonswitched multipoint line, and a switched point-to-point line.

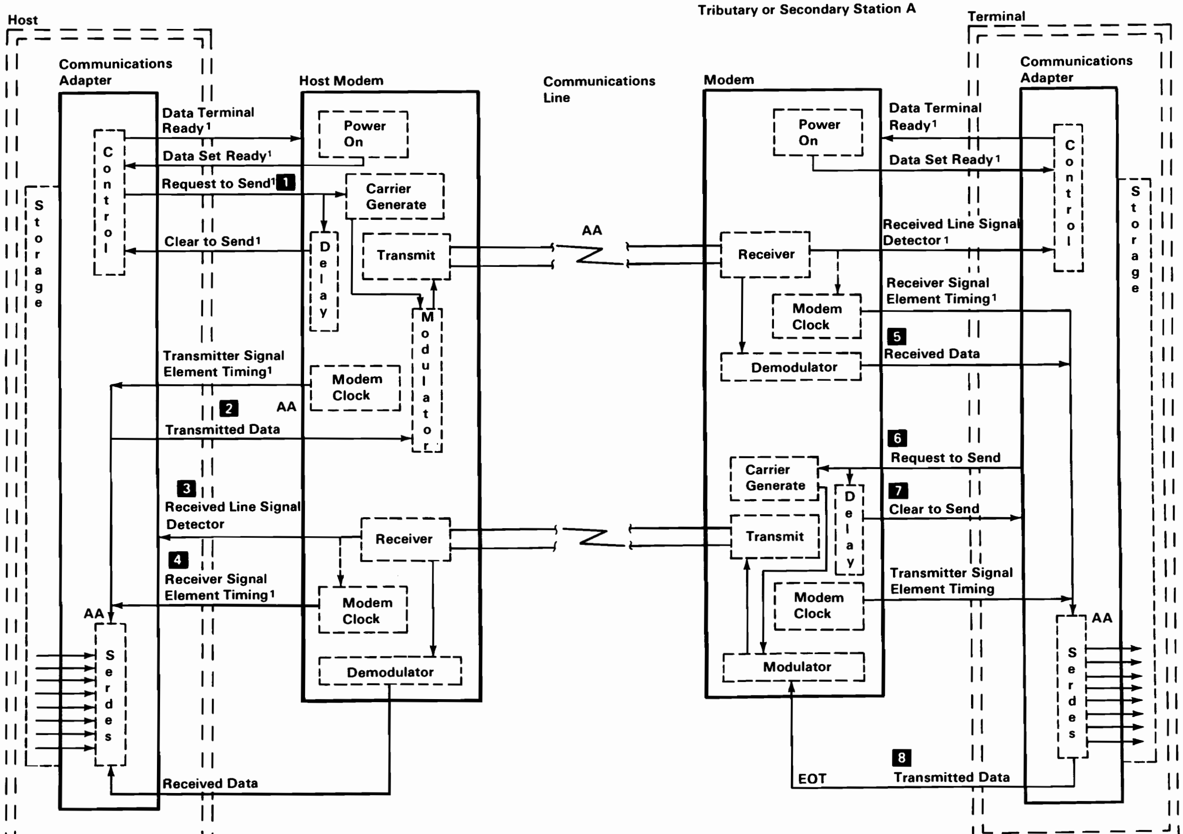
Establishing a Link on a Nonswitched Point-to-Point Line

1. The terminals at both locations activate the 'data terminal ready' lines 1 and 8.
2. Normally the 'data set ready' lines 2 and 9 from the modems are active whenever the modems are powered on.
3. Terminal A activates the 'request to send' line, which causes the modem at terminal A to generate a carrier signal.
4. Modem B detects the carrier, and activates the 'received line signal detector' line (sometimes called data carrier detect) 10. Modem B also activates the 'receiver signal element timing' line (sometimes called receive clock) 11 to send receive clock signals to the terminal. Some modems activate the clock signals whenever the modem is powered on.
5. After a specified delay, modem A activates the 'clear to send' line 4 which indicates to terminal A that the modem is ready to transmit data.
6. Terminal A serializes the data to be transmitted (through the serdes) and transmits the data one bit at a time (synchronized by the transmit clock) onto the 'transmitted data' line 6 to the modem.
7. The modem modulates the carrier signal with the data and transmits it to the modem B 5.
8. Modem B demodulates the data from the carrier signal and sends it to terminal B on the 'received data' line 12.
9. Terminal B deserializes the data (through the serdes) using the receive clock signals (on the 'receiver signal element timing' line) 11 from the modem.
10. After terminal A completes its transmission, it deactivates the 'request to send' line 3, which causes the modem to turn off the carrier and deactivate the 'clear to send' line 4.
11. Terminal A and modem A now become receivers and wait for a response from terminal B, indicating that all data has reached terminal B. Modem A begins an echo delay (50 to 150 milliseconds) to ensure that all echoes on the line have diminished before it begins receiving. An echo is a reflection of the transmitted signal. If the transmitting modem changed to receive too soon, it could receive a reflection (echo) of the signal it just transmitted.
12. Modem B deactivates the 'received line signal detector' line 10 and, if necessary, deactivates the receive clock signals on the 'receiver signal element timing, line 11.
13. Terminal B now becomes the transmitter to respond to the request from terminal A. To transmit data, terminal B activates the 'request to send' line 13, which causes modem B to transmit a carrier to modem A.
14. Modem B begins a delay that is longer than the echo delay at modem A before turning on the 'clear to send' line. The longer delay (called request-to-send delay) ensures that modem A is ready to receive when terminal B begins transmitting data. After the delay, modem B activates the 'clear to send' line 14 to indicate that terminal B can begin transmitting its response.
15. After the echo delay at modem A, modem A senses the carrier from modem B (the carrier was activated in step 13 when terminal B activated the 'request to send' line) and activates the 'received line signal detector; line 7 to terminal A.
16. Modem A and terminal A are ready to receive the response from termianl B. Remember, the response was not transmitted until after the request-to-send to clear-to-send delay at modem B (step 14).


Terminal A
Communications Adapter
Storage
Control
Serdes
Modem A
Power Supply
Carrier Generate
Delay
Transmit Circuits
Modulator
Modem Clock
Echo Delay
Receive Circuits
Modem Clock
Demodulator
1 Data Terminal Ready
2 Data Set Ready
3 Request to Send
4 Clear to Send
5
Transmitter Signal Element Timing
6 Transmitted Data
7 Received Line Signal Detector
Receiver Signal Element Timing
Received Data
Communications Line
Modem B
Power Supply
Receive Circuits
Modem Clock
Demodulator
Echo Delay
Carrier Generate
Delay
Transmit Circuits
Modem Clock
Modulator
Terminal B
Communications Adapter
Control
Storage
Serdes
8 Data Terminal Ready
9 Data Set Ready
10 Received Line Signal Detector
11 Receiver Signal Element Timing
12 Received Data
13 Request to Send
14 Clear to Send
Transmitter Signal Element Timing
Transmitted Data

Establishing a Link on a Nonswitched Multipoint Line

1. The control station serializes the address for the tributary or secondary station (AA) and sends its address to the modem on the 'transmitted data' line 2.
2. Since the 'request to send' line and, therefore, the modem carrier, is active continuously 1, the modem immediately modulates the carrier with the address, and, thus, the address is transmitted to all modems on the line.
3. All tributary modems, including the modem for station A, demodulate the address and send it to their terminals on the 'received data' line 5.
4. Only station A responds to the address; the other stations ignore the address and continue monitoring their 'received data' line. To respond to the poll, station A activates its 'request to send' line 6, which causes the modem to begin transmitting a carrier signal.
5. The control station's modem receives the carrier and activates the 'received line signal detector' line 3 and the 'receiver signal element timing' line 4 (to send clock signals to the control station). Some modems activate the clock signals as soon as they are powered on.
6. After a short delay to allow the control station modem to receive the carrier, the tributary modem activates the 'clear to send' line 7.
7. When station A detects the active 'clear to send' line, it transmits its response. (For this example, assume that station A has no data to send; therefore, it transmits an EOT 8.)
8. After transmitting the EOT, station A deactivates the 'request to send' line 6. This causes the modem to deactivate the carrier and the 'clear to send' line 7.
9. When the modem at the control station (host) detects the absence of the carrier, it deactivates the 'received line signal detector' line 3.
10. Tributary station A is now in receive mode waiting for the next poll or select transmission from the control station.

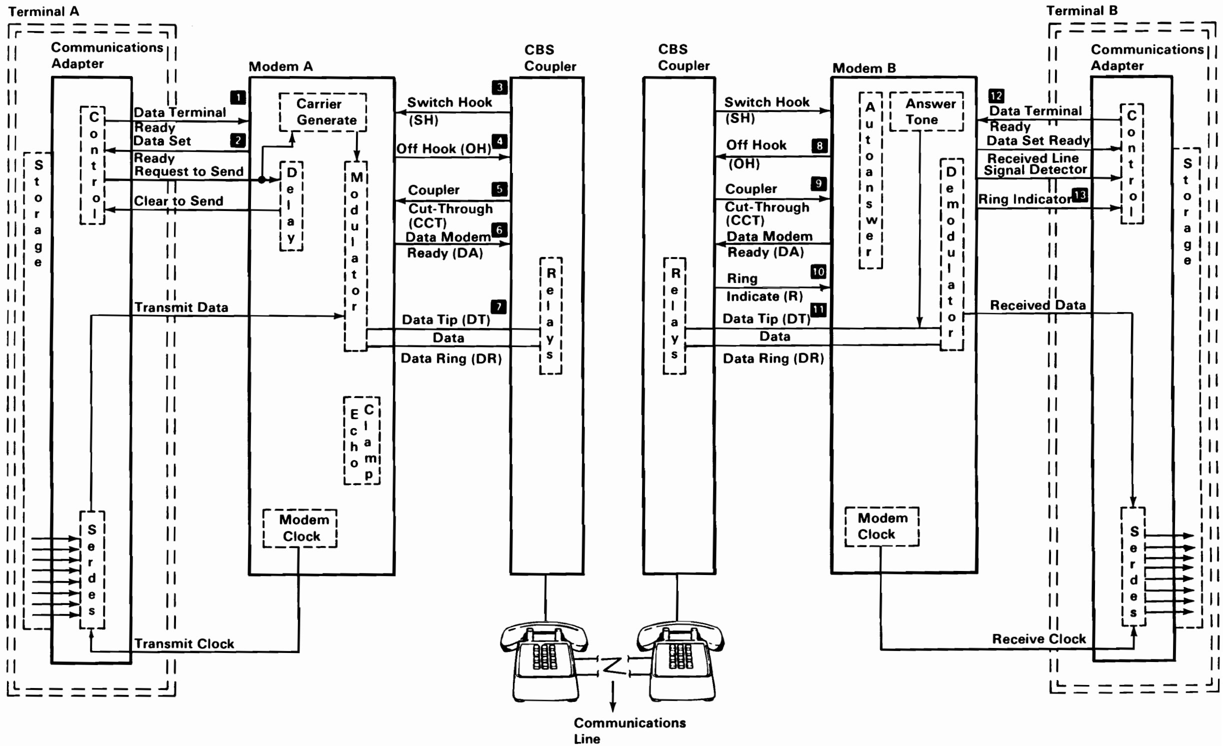


1These lines are active continuously.

Establishing a Link on a Switched Point-To-Point Line

1. Terminal A is in communications mode; therefore, the 'data terminal ready' line 1 is active. Terminal B is in communication mode waiting for a call from terminal A.
2. When the terminal A operator lifts the telephone handset, the 'switch hook' line from the coupler is activated 3.
3. Modem A detects the 'switch hook' line and activates the 'off hook' line 4, which causes the coupler to connect the telephone set to the line and activate the 'coupler cut-through' line 5 to the modem.
4. Modem A activates the 'data modem ready' line 6 to the coupler (the 'data modem ready' line is on continuously in some modems).
5. The terminal A operator sets the exclusion key or talk/data switch to the talk position to connect the handset to the communications line. The operator then dials the terminal B number.
6. When the telephone at terminal B rings, the coupler activates the 'ring indicate' line to modem B 10. Modem B indicates that the 'ring indicate' line was activated by activating the 'ring indicator' line 13 to terminal B.
7. Terminal B activates the 'data terminal ready' line to modem B 12 which activates the autoanswer circuits in modem B. (The 'data terminal ready' line might already be active in some terminals.)
8. The autoanswer circuits in modem B activate the 'off hook' line to the coupler 8.
9. The coupler connects modem B to the communications line through the 'data tip' and 'data ring' lines 11 and activates the 'coupler cut-through' line 9 to the modem. Modem B then transmits an answer tone to terminal A.
10. The terminal A operator hears the tone and sets the exclusion key or talk/data switch to the data position (or performs an equivalent operation) to connect modem A to the communications line through the 'data tip' and 'data ring' lines 7.
11. The coupler at terminal A deactivates the 'switch hook' line 3. This causes modem A to activate the 'data set ready' line 2 indicating to terminal A that the modem is connected to the communications line.

The sequence of the remaining steps to establish the data link is the same as the sequence required on a nonswitched point-to-point line. When the terminals have completed their transmission, they both deactivate the 'data terminal ready' line to disconnect the modems from the line.



Terminal A
Communications Adapter
Storage
Control
Serdes
Modem A
Carrier Generate
Delay
Modulator
Echo Clamp
Modem Clock
Data Terminal Ready
Data Set Ready
Request to Send
Clear to Send
Transmit Data
Transmit Clock
CBS Coupler
Switch Hook (SH)
Off Hook (OH)
Coupler Cut-Through (CCT)
Data Modem Ready (DA)
Data Tip (DT)
Data
Data Ring (DR)
Relays
Communications Line
CBS Coupler
Relays
Switch Hook (SH)
Off Hook (OH)
Coupler Cut-Through (CCT)
Data Modem Ready (DA)
Ring Indicate (R)
Data Tip (DT)
Data
Data Ring (DR)
Modem B
Autoanswer
Answer Tone
Demodulator
Modem Clock
Terminal B
Communications Adapter
Control
Storage
Serdes
Data Terminal Ready
Data Set Ready
Received Line Signal Detector
Ring Indicator
Received Data
Receive Clock
1
2
3
4
5
6
7
8
9
10
11
12
13

Notes:

Glossary

μ. Prefix micro; 0.000 001.

μs. Microsecond; 0.000 001 second.

A. Ampere.

ac. Alternating current.

accumulator. A register in which the result of an operation is formed.

active high. Designates a signal that has to go high to produce an effect. Synonymous with positive true.

active low. Designates a signal that has to go low to produce an effect. Synonymous with negative true.

adapter. An auxiliary device or unit used to extend the operation of another system.

address bus. One or more conductors used to carry the binary-coded address from the processor throughout the rest of the system.

algorithm. A finite set of well-defined rules for the solution of a problem in a finite number of steps.

all points addressable (APA). A mode in which all points of a displayable image can be controlled by the user.

alphameric. Synonym for alphanumeric.

alphanumeric (A/N). Pertaining to a character set that contains letters, digits, and usually other characters, such as punctuation marks. Synonymous with alphameric.

alternating current (ac). A current that periodically reverses its direction of flow.

American National Standard Code for Information Exchange (ASCII). The standard code, using a coded character set consisting of 7-bit coded characters (8 bits including parity check), used for information exchange between data processing systems, data communication systems, and associated equipment. The ASCII set consists of control characters and graphic characters.

ampere (A). The basic unit of electric current.

A/N. Alphanumeric

analog. (1) Pertaining to data in the form of continuously variable physical quantities. (2) Contrast with digital.

AND. A logic operator having the property that if P is a statement, Q is a statement, R is a statement,..., then the AND of P, Q, R,...is true if all statements are true, false if any statement is false.

AND gate. A logic gate in which the output is 1 only if all inputs are 1.

AND operation. The boolean operation whose result has the boolean value 1, if and only if, each operand has the boolean value 1. Synonymous with conjunction.

APA. All points addressable.

ASCII. American National Standard Code for Information Exchange.

assemble. To translate a program expressed in an assembler language into a computer language.

assembler. A computer program used to assemble.

assembler language. A computer-oriented language whose instructions are usually in one-to-one correspondence with computer instructions.

asynchronous transmission. (1) Transmission in which the time of occurrence of the start of each character, or block of characters, is arbitrary; once started, the time of occurrence of each signal representing a bit within a character, or block, has the same relationship to significant instants of a fixed time frame. (2) Transmission in which each information character is individually transmitted (usually timed by the use of start elements and stop elements).

audio frequencies. Frequencies that can be heard by the human ear (approximately 15 hertz to 20 000 hertz).

auxiliary storage. (1) A storage device that is not main storage. (2) Data storage other than main storage; for example, storage on magnetic disk. (3) Contrast with main storage.

BASIC. Beginner's all-purpose symbolic instruction code.

basic input/output system (BIOS). The feature of the IBM Personal Computer that provides the level control of the major I/O devices, and relieves the programmer from concern about hardware device characteristics.

baud. (1) A unit of signaling speed equal to the number of discrete conditions or signal events per second. For example, one baud equals one bit per second in a train of binary signals, one-half dot cycle per second in Morse code, and one 3-bit value per second in a train of signals each of which can assume one of eight different states. (2) In asynchronous transmission, the unit of modulation rate corresponding to one unit of interval per second; that is, if the duration of the unit interval is 20 milliseconds, the modulation rate is 50 baud.

BCC. Block-check character.

beginner's all-purpose symbolic instruction code (BASIC). A programming language with a small repertoire of commands and a simple syntax, primarily designed for numeric applications.

binary. (1) Pertaining to a selection, choice, or condition that has two possible values or states. (2) Pertaining to a fixed radix numeration system having a radix of 2.

binary digit. (1) In binary notation, either of the characters 0 or 1. (2) Synonymous with bit.

binary notation. Any notation that uses two different characters, usually the binary digits 0 and 1.

binary synchronous communications (BSC). A uniform procedure, using a standardized set of control characters and control character sequences for synchronous transmission of binary–coded data between stations.

BIOS. Basic input/output system.

bit. Synonym for binary digit

bits per second (bps). A unit of measurement representing the number of discrete binary digits transmitted by a device in one second.

block. (1) A string of records, a string of words, or a character string formed for technical or logic reasons to be treated as an entity. (2) A set of things, such as words, characters, or digits, treated as a unit.

block-check character (BCC). In cyclic redundancy checking, a character that is transmitted by the sender after each message block and is compared with a block-check character computed by the receiver to determine if the transmission was successful.

boolean operation. (1) Any operation in which each of the operands and the result take one of two values. (2) An operation that follows the rules of boolean algebra.

bootstrap. A technique or device designed to bring itself into a desired state by means of its own action; for example, a machine routine whose first few instructions are sufficient to bring the rest of itself into the computer from an input device.

bps. Bits per second.

BSC. Binary synchronous communications.

buffer. (1) An area of storage that is temporarily reserved for use in performing an input/output operation, into which data is read or from which data is written. Synonymous with I/O area. (2) A portion of storage for temporarily holding input or output data.

bus. One or more conductors used for transmitting signals or power.

byte. (1) A sequence of eight adjacent binary digits that are operated upon as a unit. (2) A binary character operated upon as a unit. (3) The representation of a character.

C. Celsius.

capacitor. An electronic circuit component that stores an electric charge.

CAS. Column address strobe.

cathode ray tube (CRT). A vacuum tube in which a stream of electrons is projected onto a fluorescent screen producing a luminous spot. The location of the spot can be controlled.

cathode ray tube display (CRT display). (1) A CRT used for displaying data. For example, the electron beam can be controlled to form alphanumeric data by use of a dot matrix. (2) The data display produced by the device as in (1).

CCITT. International Telegraph and Telephone Consultative Committee.

Celsius (C). A temperature scale. Contrast with Fahrenheit (F).

central processing unit (CPU). Term for processing unit.

channel. A path along which signals can be sent; for example, data channel, output channel.

character generator. (1) In computer graphics, a functional unit that converts the coded representation of a graphic character into the shape of the character for display. (2) In word processing, the means within equipment for generating visual characters or symbols from coded data.

character set. (1) A finite set of different characters upon which agreement has been reached and that is considered complete for some purpose. (2) A set of unique representations called characters. (3) A defined collection of characters.

characters per second (cps). A standard unit of measurement for the speed at which a printer prints.

check key. A group of characters, derived from and appended to a data item, that can be used to detect errors in the data item during processing.

closed circuit. A continuous unbroken circuit; that is, one in which current can flow. Contrast with open circuit.

CMOS. Complementary metal oxide semiconductor.

code. (1) A set of unambiguous rules specifying the manner in which data may be represented in a discrete form. Synonymous with coding scheme. (2) A set of items, such as abbreviations, representing the members of another set. (3) To represent data or a computer program in a symbolic form that can be accepted by a data processor. (4) Loosely, one or more computer programs, or part of a computer program.

coding scheme. Synonym for code.

collector. An element in a transistor toward which current flows.

column address strobe (CAS). A signal that latches the column addresses in a memory chip.

compile. (1) To translate a computer program expressed in a problem-oriented language into a computer-oriented language. (2) To prepare a machine-language program from a computer program written in another programming language by making use of the overall logic structure of the program, or generating more than one computer instruction for each symbolic statement, or both, as well as performing the function of an assembler.

complementary metal oxide semiconductor (CMOS). A logic circuit family that uses very little power. It works with a wide range of power supply voltages.

computer. A functional unit that can perform substantial computation, including numerous arithmetic operations or logic operations, without intervention by a human operator during a run.

computer instruction code. A code used to represent the instructions in an instruction set. Synonymous with machine code.

computer program. A sequence of instructions suitable for processing by a computer.

computer word. A word stored in one computer location and capable of being treated as a unit.

configuration. (1) The arrangement of a computer system or network as defined by the nature, number, and the chief characteristics of its functional units. More specifically, the term configuration may refer to a hardware configuration or a software configuration. (2) The devices and programs that make up a system, subsystem, or network.

conjunction. Synonym for AND operation.

contiguous. Touching or joining at the edge or boundary; adjacent.

control character. A character whose occurrence in a particular context initiates, modifies, or stops a control operation.

control operation. An action that affects the recording, processing, transmission, or interpretation of data; for example, starting or stopping a process, carriage return, font change, rewind, and end of transmission.

control storage. A portion of storage that contains microcode.

cps. Characters per second.

CPU. Central processing unit.

CRC. Cyclic redundancy check.

CRT. Cathode ray tube.

CRT display. Cathode ray tube display.

CTS. Clear to send. Associated with modem control.

cursor. (1) In computer graphics, a movable marker that is used to indicate a position on a display. (2) A displayed symbol that acts as a marker to help the user locate a point in text, in a system command, or in storage. (3) A movable spot of light on the screen of a display device, usually indicating where the next character is to be entered, replaced, or deleted.

cyclic redundancy check (CRC). (1) A redundancy check in which the check key is generated by a cyclic algorithm. (2) A system of error checking performed at both the sending and receiving station after a block-check character has been accumulated.

cylinder. (1) The set of all tracks with the same nominal distance from the axis about which the disk rotates. (2) The tracks of a disk storage device that can be accessed without repositioning the access mechanism.

daisy-chained cable. A type of cable that has two or more connectors attached in series.

data. (1) A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by human or automatic means. (2) Any representations, such as characters or analog quantities, to which meaning is, or might be assigned.

data base. A collection of data that can be immediately accessed and operated upon by a data processing system for a specific purpose.

data processing system. A system that performs input, processing, storage, output, and control functions to accomplish a sequence of operations on data.

data transmission. Synonym for transmission.

dB. Decibel.

dBa. Adjusted decibels.

dc. Direct current.

debounce. An electronic means of overcoming the make/break bounce of switches to obtain one smooth change of signal level.

decibel. (1) A unit that expresses the ratio of two power levels on a logarithmic scale. (2) A unit for measuring relative power.

decoupling capacitor. A capacitor that provides a low impedance path to ground to prevent common coupling between circuits.

Deutsche Industrie Norm (DIN). (1) German Industrial Norm. (2) The committee that sets German dimension standards.

digit. (1) A graphic character that represents an integer; for example, one of the characters 0 to 9. (2) A symbol that represents one of the non-negative integers smaller than the radix. For example, in decimal notation, a digit is one of the characters 0 to 9.

digital. (1) Pertaining to data in the form of digits. (2) Contrast with analog.

DIN. Deutsche Industrie Norm.

DIN connector. One of the connectors specified by the DIN committee.

DIP. Dual in-line package.

DIP switch. One of a set of small switches mounted in a dual in-line package.

direct current (dc). A current that always flows in one direction.

direct memory access (DMA). A method of transferring data between main storage and I/O devices that does not require processor intervention.

disable. To stop the operation of a circuit or device.

disabled. Pertaining to a state of a processing unit that prevents the occurrence of certain types of interruptions. Synonymous with masked.

disk. Loosely, a magnetic disk.

diskette. A thin, flexible magnetic disk and a semirigid protective jacket, in which the disk is permanently enclosed. Synonymous with flexible disk.

diskette drive. A device for storing data on and retrieving data from a diskette.

display. (1) A visual presentation of data. (2) A device for visual presentation of information on any temporary character imaging device. (3) To present data visually. (4) See cathode ray tube display.

display attribute. In computer graphics, a particular property that is assigned to all or part of a display; for example, low intensity, green color, blinking status.

DMA. Direct memory access.

dot matrix. (1) In computer graphics, a two-dimensional pattern of dots used for constructing a display image. This type of matrix can be used to represent characters by dots. (2) In word processing, a pattern of dots used to form characters. This term normally refers to a small section of a set of addressable points; for example, a representation of characters by dots.

dot printer. Synonym for matrix printer.

dot-matrix character generator. In computer graphics, a character generator that generates character images composed of dots.

DSR. Data set ready. Associated with modem control.

DTR. In the IBM Personal Computer, data terminal ready. Associated with modem control.

dual in-line package (DIP). A widely used container for an integrated circuit. DIPs have pins in two parallel rows. The pins are spaced 1/10 inch apart. See also DIP switch.

duplex. (1) In data communication, pertaining to a simultaneous two-way independent transmission in both directions. (2) Contrast with half-duplex.

duty cycle. In the operation of a device, the ratio of on time to idle time. Duty cycle is expressed as a decimal or percentage.

dynamic memory. RAM using transistors and capacitors as the memory elements. This memory requires a refresh (recharge) cycle every few milliseconds. Contrast with static memory.

EBCDIC. Extended binary-coded decimal interchange code.

ECC. Error checking and correction.

edge connector. A terminal block with a number of contacts attached to the edge of a printed-circuit board to facilitate plugging into a foundation circuit.

EIA. Electronic Industries Association.

electromagnet. Any device that exhibits magnetism only while an electric current flows through it.

enable. To initiate the operation of a circuit or device.

end of block (EOB). A code that marks the end of a block of data.

end of file (EOF). An internal label, immediately following the last record of a file, signaling the end of that file. It may include control totals for comparison with counts accumulated during processing.

end-of-text (ETX). A transmission control character used to terminate text.

end-of-transmission (EOT). A transmission control character used to indicate the conclusion of a transmission, which may have included one or more texts and any associated message headings.

end-of-transmission-block (ETB). A transmission control character used to indicate the end of a transmission block of data when data is divided into such blocks for transmission purposes.

EOB. End of block.

EOF. End of file.

EOT. End-of-transmission.

EPROM. Erasable programmable read-only memory.

erasable programmable read-only memory (EPROM). A PROM in which the user can erase old information and enter new information.

error checking and correction (ECC). The detection and correction of all single-bit errors, plus the detection of double-bit and some multiple-bit errors.

ESC. The escape character.

escape character (ESC). A code extension character used, in some cases, with one or more succeeding characters to indicate by some convention or agreement that the coded representations following the character or the group of characters are to be interpreted according to a different code or according to a different coded character set.

ETB. End-of-transmission-block.

ETX. End-of-text.

extended binary-coded decimal interchange code (EBCDIC). A set of 256 characters, each represented by eight bits.

F. Fahrenheit.

Fahrenheit (F). A temperature scale. Contrast with Celsius (C).

falling edge. Synonym for negative-going edge.

FCC. Federal Communications Commission.

fetch. To locate and load a quantity of data from storage.

FF. The form feed character.

field. (1) In a record, a specified area used for a particular category of data. (2) In a data base, the smallest unit of data that can be referred to.

fixed disk drive. In the IBM Personal Computer, a unit consisting of nonremovable magnetic disks, and a device for storing data on and retrieving data from the disks.

flag. (1) Any of various types of indicators used for identification. (2) A character that signals the occurrence of some condition, such as the end of a word. (3) Deprecated term for mark.

flexible disk. Synonym for diskette.

flip-flop. A circuit or device containing active elements, capable of assuming either one of two stable states at a given time.

font. A family or assortment of characters of a given size and style; for example, 10 point Press Roman medium.

foreground. (1) In multiprogramming, the environment in which high-priority programs are executed. (2) On a color display screen, the characters as opposed to the background.

form feed. (1) Paper movement used to bring an assigned part of a form to the printing position. (2) In word processing, a function that advances the typing position to the same character position on a predetermined line of the next form or page.

form feed character. A control character that causes the print or display position to move to the next predetermined first line on the next form, the next page, or the equivalent.

format. The arrangement or layout of data on a data medium.

frame. (1) In SDLC, the vehicle for every command, every response, and all information that is transmitted using SDLC procedures. Each frame begins and ends with a flag. (2) In data transmission, the sequence of contiguous bits bracketed by and including beginning and ending flag sequences.

g. Gram.

G. (1) Prefix giga; 1 000 000 000. (2) When referring to computer storage capacity, 1 073 741 824. (1 073 741 824 = 2 to the 30th power.)

gate. (1) A combinational logic circuit having one output channel and one or more input channels, such that the output channel state is completely determined by the input channel states. (2) A signal that enables the passage of other signals through a circuit.

Gb. 1 073 741 824 bytes.

general-purpose register. A register, usually explicitly addressable within a set of registers, that can be used for different purposes; for example, as an accumulator, as an index register, or as a special handler of data.

giga (G). Prefix 1 000 000 000.

gram (g). A unit of weight (equivalent to 0.035 ounces).

graphic. A symbol produced by a process such as handwriting, drawing, or printing.

graphic character. A character, other than a control character, that is normally represented by a graphic.

half-duplex. (1) In data communication, pertaining to an alternate, one way at a time, independent transmission. (2) Contrast with duplex.

hardware. (1) Physical equipment used in data processing, as opposed to programs, procedures, rules, and associated documentation. (2) Contrast with software.

head. A device that reads, writes, or erases data on a storage medium; for example, a small electromagnet used to read, write, or erase data on a magnetic disk.

hertz (Hz). A unit of frequency equal to one cycle per second.

hex. Common abbreviation for hexadecimal.

hexadecimal. (1) Pertaining to a selection, choice, or condition that has 16 possible different values or states. These values or states are usually symbolized by the ten digits 0 through 9 and the six letters A through F. (2) Pertaining to a fixed radix numeration system having a radix of 16.

high impedance state. A state in which the output of a device is effectively isolated from the circuit.

highlighting. In computer graphics, emphasizing a given display group by changing its attributes relative to other display groups in the same display field.

high-order position. The leftmost position in a string of characters. See also most-significant digit.

housekeeping. Operations or routines that do not contribute directly to the solution of the problem but do contribute directly to the operation of the computer.

Hz. Hertz

image. A fully processed unit of operational data that is ready to be transmitted to a remote unit; when loaded into control storage in the remote unit, the image determines the operations of the unit.

immediate instruction. An instruction that contains within itself an operand for the operation specified, rather than an address of the operand.

index register. A register whose contents may be used to modify an operand address during the execution of computer instructions.

indicator. (1) A device that may be set into a prescribed state, usually according to the result of a previous process or on the occurrence of a specified condition in the equipment, and that usually gives a visual or other indication of the existence of the prescribed state, and that may in some cases be used to determine the selection among alternative processes; for example, an overflow indicator. (2) An item of data that may be interrogated to determine whether a particular condition has been satisfied in the execution of a computer program; for example, a switch indicator, an overflow indicator.

inhibited. (1) Pertaining to a state of a processing unit in which certain types of interruptions are not allowed to occur. (2) Pertaining to the state in which a transmission control unit or an audio response unit cannot accept incoming calls on a line.

initialize. To set counters, switches, addresses, or contents of storage to 0 or other starting values at the beginning of, or at prescribed points in, the operation of a computer routine.

input/output (I/O). (1) Pertaining to a device or to a channel that may be involved in an input process, and, at a different time, in an output process. In the English language, "input/output" may be used in place of such terms as "input/output, data" "input/output signal," and "input/output terminals," when such usage is clear in a given context. (2) Pertaining to a device whose parts can be performing an input process and an output process at the same time. (3) Pertaining to either input or output, or both.

instruction. In a programming language, a meaningful expression that specifies one operation and identifies its operands, if any.

instruction set. The set of instructions of a computer, of a programming language, or of the programming languages in a programming system.

interface. A device that alters or converts actual electrical signals between distinct devices, programs, or systems.

interleave. To arrange parts of one sequence of things or events so that they alternate with parts of one or more other sequences of the same nature and so that each sequence retains its identity.

interrupt. (1) A suspension of a process, such as the execution of a computer program, caused by an event external to that process, and performed in such a way that the process can be resumed. (2) In a data transmission, to take an action at a receiving station that causes the transmitting station to terminate a transmission. (3) Synonymous with interruption.

I/O. Input/output.

I/O area. Synonym for buffer.

irrecoverable error. An error that makes recovery impossible without the use of recovery techniques external to the computer program or run.

joystick. In computer graphics, a lever that can pivot in all directions and that is used as a locator device.

k. Prefix kilo; 1000.

K. When referring to storage capacity, 1024. (1024 = 2 to the 10th power.)

Kb. 1024 bytes.

kg. Kilogram; 1000 grams.

kHz. Kilohertz; 1000 hertz.

kilo (k). Prefix 1000

kilogram (kg). 1000 grams.

kilohertz (kHz). 1000 hertz

latch. (1) A simple logic-circuit storage element. (2) A feedback loop in sequential digital circuits used to maintain a state.

least-significant digit. The rightmost digit. See also low-order position.

LED. Light-emitting diode.

light-emitting diode (LED). A semiconductor device that gives off visible or infrared light when activated.

load. In programming, to enter data into storage or working registers.

low power Schottky TTL. A version (LS series) of TTL giving a good compromise between low power and high speed. See also transistor-transistor logic and Schottky TTL.

low-order position. The rightmost position in a string of characters. See also least-significant digit.

m. (1) Prefix milli; 0.001. (2) Meter.

M. (1) Prefix mega; 1 000 000. (2) When referring to computer storage capacity, 1 048 576. (1 048 576 = 2 to the 20th power.)

mA. Milliampere; 0.001 ampere.

machine code. The machine language used for entering text and program instructions onto the recording medium or into storage and which is subsequently used for processing and printout.

machine language. (1) A language that is used directly by a machine. (2) Deprecated term for computer instruction code.

magnetic disk. (1) A flat circular plate with a magnetizable surface layer on which data can be stored by magnetic recording. (2) See also diskette.

main storage. (1) Program-addressable storage from which instructions and other data can be loaded directly into registers for subsequent execution or processing. (2) Contrast with auxiliary storage.

mark. A symbol or symbols that indicate the beginning or the end of a field, of a word, of an item of data, or of a set of data such as a file, a record, or a block.

mask. (1) A pattern of characters that is used to control the retention or elimination of portions of another pattern of characters. (2) To use a pattern of characters to control the retention or elimination of portions of another pattern of characters.

masked. Synonym for disabled.

matrix. (1) A rectangular array of elements, arranged in rows and columns, that may be manipulated according to the rules of matrix algebra. (2) In computers, a logic network in the form of an array of input leads and output leads with logic elements connected at some of their intersections.

matrix printer. A printer in which each character is represented by a pattern of dots; for example, a stylus printer, a wire printer. Synonymous with dot printer.

Mb. 1 048 576 bytes.

mega (M). Prefix 1 000 000.

megahertz (MHz). 1 000 000 hertz.

memory. Term for main storage.

meter (m). A unit of length (equivalent to 39.37 inches).

MFM. Modified frequency modulation.

MHz. Megahertz; 1 000 000 hertz.

micro (μ). Prefix 0.000 001.

microcode. (1) One or more microinstructions. (2) A code, representing the instructions of an instruction set, implemented in a part of storage that is not program-addressable.

microinstruction. (1) An instruction of microcode. (2) A basic or elementary machine instruction.

microprocessor. An integrated circuit that accepts coded instructions for execution; the instructions may be entered, integrated, or stored internally.

microsecond (μs). 0.000 001 second.

milli (m). Prefix 0.001.

milliampere (mA). 0.001 ampere.

millisecond (ms). 0.001 second.

mnemonic. A symbol chosen to assist the human memory; for example, an abbreviation such as "mpy" for "multiply".

mode. (1) A method of operation; for example, the binary mode, the interpretive mode, the alphanumeric mode. (2) The most frequent value in the statistical sense.

modem (modulator-demodulator). A device that converts serial (bit by bit) digital signals from a business machine (or data communication equipment) to analog signals that are suitable for transmission in a telephone network. The inverse function is also performed by the modem on reception of analog signals.

modified frequency modulation (MFM). The process of varying the amplitude and frequency of the 'write' signal. MFM pertains to the number of bytes of storage that can be stored on the recording media. The number of bytes is twice the number contained in the same unit area of recording media at single density.

modulation. The process by which some characteristic of one wave (usually high frequency) is varied in accordance with another wave or signal (usually low frequency). This technique is used in modems to make business-machine signals compatible with communication facilities.

modulation rate. The reciprocal of the measure of the shortest nominal time interval between successive significant instants of the modulated signal. If this measure is expressed in seconds, the modulation rate is expressed in baud.

module. (1) A program unit that is discrete and identifiable with respect to compiling, combining with other units, and loading. (2) A packaged functional hardware unit designed for use with other components.

modulo check. A calculation performed on values entered into a system. This calculation is designed to detect errors.

monitor. (1) A device that observes and verifies the operation of a data processing system and indicates any significant departure from the norm. (2) Software or hardware that observes, supervises, controls, or verifies the operations of a system.

most-significant digit. The leftmost (non-zero) digit. See also high-order position.

ms. Millisecond; 0.001 second.

multiplexer. A device capable of interleaving the events of two or more activities, or capable of distributing the events of an interleaved sequence to the respective activities.

multiprogramming. (1) Pertaining to the concurrent execution of two or more computer programs by a computer. (2) A mode of operation that provides for the interleaved execution of two or more computer programs by a single processor.

n. Prefix nano; 0.000 000 001.

NAND. A logic operator having the property that if P is a statement, Q is a statement, R is a statement,..., then the NAND of P, Q ,R,... is true if at least one statement is false, false if all statements are true.

NAND gate. A gate in which the output is 0 only if all inputs are 1.

nano (n). Prefix 0.000 000 001.

nanosecond (ns). 0.000 000 001 second.

negative true. Synonym for active low.

negative-going edge. The edge of a pulse or signal changing in a negative direction. Synonymous with falling edge.

non-return-to-zero change-on-ones recording (NRZI). A transmission encoding method in which the data terminal equipment changes the signal to the opposite state to send a binary 1 and leaves it in the same state to send a binary 0.

non-return-to-zero (inverted) recording (NRZI). Deprecated term for non-return-to-zero change-on-ones recording.

NOR. A logic operator having the property that if P is a statement, Q is a statement, R is a statement,..., then the NOR of P, Q, R,... is true if all statements are false, false if at least one statement is true.

NOR gate. A gate in which the output is 0 only if at least one input is 1.

NOT. A logical operator having the property that if P is a statement, then the NOT of P is true if P is false, false if P is true.

NRZI. Non-return-to-zero change-on-ones recording.

ns. Nanosecond; 0.000 000 001 second.

NUL. The null character.

null character (NUL). A control character that is used to accomplish media-fill or time-fill, and that may be inserted into or removed from, a sequence of characters without affecting the meaning of the sequence; however, the control of the equipment or the format may be affected by this character.

odd-even check. Synonym for parity check.

offline. Pertaining to the operation of a functional unit without the continual control of a computer.

one-shot. A circuit that delivers one output pulse of desired duration for each input (trigger) pulse.

open circuit. (1) A discontinuous circuit; that is, one that is broken at one or more points and, consequently, cannot conduct current. Contrast with closed circuit. (2) Pertaining to a no-load condition; for example, the open-circuit voltage of a power supply.

open collector. A switching transistor without an internal connection between its collector and the voltage supply. A connection from the collector to the voltage supply is made through an external (pull-up) resistor.

operand. (1) An entity to which an operation is applied. (2) That which is operated upon. An operand is usually identified by an address part of an instruction.

operating system. Software that controls the execution of programs; an operating system may provide services such as resource allocation, scheduling, input/output control, and data management.

OR. A logic operator having the property that if P is a statement, Q is a statement, R is a statement,..., then the OR of P, Q, R,...is true if at least one statement is true, false if all statements are false.

OR gate. A gate in which the output is 1 only if at least one input is 1.

output. Pertaining to a device, process, or channel involved in an output process, or to the data or states involved in an output process.

output process. (1) The process that consists of the delivery of data from a data processing system, or from any part of it. (2) The return of information from a data processing system to an end user, including the translation of data from a machine language to a language that the end user can understand.

overcurrent. A current of higher than specified strength.

overflow indicator. (1) An indicator that signifies when the last line on a page has been printed or passed. (2) An indicator that is set on if the result of an arithmetic operation exceeds the capacity of the accumulator.

overrun. Loss of data because a receiving device is unable to accept data at the rate it is transmitted.

overvoltage. A voltage of higher than specified value.

parallel. (1) Pertaining to the concurrent or simultaneous operation of two or more devices, or to the concurrent performance of two or more activities. (2) Pertaining to the concurrent or simultaneous occurrence of two or more related activities in multiple devices or channels. (3) Pertaining to the simultaneity of two or more processes. (4) Pertaining to the simultaneous processing of the individual parts of a whole, such as the bits of a character and the characters of a word, using separate facilities for the various parts. (5) Contrast with serial.

parameter. (1) A variable that is given a constant value for a specified application and that may denote the application. (2) A name in a procedure that is used to refer to an argument passed to that procedure.

parity bit. A binary digit appended to a group of binary digits to make the sum of all the digits either always odd (odd parity) or always even (even parity).

parity check. (1) A redundancy check that uses a parity bit. (2) Synonymous with odd-even check.

PEL. Picture element.

personal computer. A small home or business computer that has a processor and keyboard and that can be connected to a television or some other monitor. An optional printer is usually available.

phototransistor. A transistor whose switching action is controlled by light shining on it.

picture element (PEL). The smallest displayable unit on a display.

polling. (1) Interrogation of devices for purposes such as to avoid contention, to determine operational status, or to determine readiness to send or receive data. (2) The process whereby stations are invited, one at a time, to transmit.

port. An access point for data entry or exit.

positive true. Synonym for active high.

positive-going edge. The edge of a pulse or signal changing in a positive direction. Synonymous with rising edge.

potentiometer. A variable resistor with three terminals, one at each end and one on a slider (wiper).

power supply. A device that produces the power needed to operate electronic equipment.

printed circuit. A pattern of conductors (corresponding to the wiring of an electronic circuit) formed on a board of insulating material.

printed-circuit board. A usually copper-clad plastic board used to make a printed circuit.

priority. A rank assigned to a task that determines its precedence in receiving system resources.

processing program. A program that performs such functions as compiling, assembling, or translating for a particular programming language.

processing unit. A functional unit that consists of one or more processors and all or part of internal storage.

processor. (1) In a computer, a functional unit that interprets and executes instructions. (2) A functional unit, a part of another unit such as a terminal or a processing unit, that interprets and executes instructions. (3) Deprecated term for processing program. (4) See microprocessor.

program. (1) A series of actions designed to achieve a certain result. (2) A series of instructions telling the computer how to handle a problem or task. (3) To design, write, and test computer programs.

programmable read-only memory (PROM). A read-only memory that can be programmed by the user.

programming language. (1) An artificial language established for expressing computer programs. (2) A set of characters and rules with meanings assigned prior to their use, for writing computer programs.

programming system. One or more programming languages and the necessary software for using these languages with particular automatic data-processing equipment.

PROM. Programmable read-only memory.

propagation delay. (1) The time necessary for a signal to travel from one point on a circuit to another. (2) The time delay between a signal change at an input and the corresponding change at an output.

protocol. (1) A specification for the format and relative timing of information exchanged between communicating parties. (2) The set of rules governing the operation of functional units of a communication system that must be followed if communication is to be achieved.

pulse. A variation in the value of a quantity, short in relation to the time schedule of interest, the final value being the same as the initial value.

radio frequency (RF). An ac frequency that is higher than the highest audio frequency. So called because of the application to radio communication.

radix. (1) In a radix numeration system, the positive integer by which the weight of the digit place is multiplied to obtain the weight of the digit place with the next higher weight; for example, in the decimal numeration system the radix of each digit place is 10. (2) Another term for base.

radix numeration system. A positional representation system in which the ratio of the weight of any one digit place to the weight of the digit place with the next lower weight is a positive integer (the radix). The permissible values of the character in any digit place range from 0 to one less than the radix.

RAM. Random access memory. Read/write memory.

random access memory (RAM). Read/write memory.

RAS. In the IBM Personal Computer, row address strobe.

raster. In computer graphics, a predetermined pattern of lines that provides uniform coverage of a display space.

read. To acquire or interpret data from a storage device, from a data medium, or from another source.

read-only memory (ROM). A storage device whose contents cannot be modified. The memory is retained when power is removed.

read/write memory. A storage device whose contents can be modified. Also called RAM.

recoverable error. An error condition that allows continued execution of a program.

red-green-blue-intensity (RGBI). The description of a direct-drive color monitor that accepts input signals of red, green, blue, and intensity.

redundancy check. A check that depends on extra characters attached to data for the detection of errors. See cyclic redundancy check.

register. (1) A storage device, having a specified storage capacity such as a bit, a byte, or a computer word, and usually intended for a special purpose. (2) A storage device in which specific data is stored.

retry. To resend the current block of data (from the last EOB or ETB) a prescribed number of times, or until it is entered correctly or accepted.

reverse video. A form of highlighting a character, field, or cursor by reversing the color of the character, field, or cursor with its background; for example, changing a red character on a black background to a black character on a red background.

RF. Radio frequency.

RF modulator. The device used to convert the composite video signal to the antenna level input of a home TV.

RGBI. Red-green-blue-intensity.

rising edge. Synonym for positive-going edge.

ROM. Read-only memory.

ROM/BIOS. The ROM resident basic input/output system, which provides the level control of the major I/O devices in the computer system.

row address strobe (RAS). A signal that latches the row address in a memory chip.

RS-232C. A standard by the EIA for communication between computers and external equipment.

RTS. Request to send. Associated with modem control.

run. A single continuous performance of a computer program or routine.

schematic. The representation, usually in a drawing or diagram form, of a logical or physical structure.

Schottky TTL. A version (S series) of TTL with faster switching speed, but requiring more power. See also transistor-transistor logic and low power Schottky TTL.

SDLC. Synchronous Data Link Control

sector. That part of a track or band on a magnetic drum, a magnetic disk, or a disk pack that can be accessed by the magnetic heads in the course of a predetermined rotational displacement of the particular device.

SERDES. Serializer/deserializer.

serial. (1) Pertaining to the sequential performance of two or more activities in a single device. In English, the modifiers serial and parallel usually refer to devices, as opposed to sequential and consecutive, which refer to processes. (2) Pertaining to the sequential or consecutive occurrence of two or more related activities in a single device or channel. (3) Pertaining to the sequential processing of the individual parts of a whole, such as the bits of a character or the characters of a word, using the same facilities for successive parts. (4) Contrast with parallel.

serializer/deserializer (SERDES). A device that serializes output from, and deserializes input to, a business machine.

setup. (1) In a computer that consists of an assembly of individual computing units, the arrangement of interconnections between the units, and the adjustments needed for the computer to operate. (2) The preparation of a computing system to perform a job or job step. Setup is usually performed by an operator and often involves performing routine functions, such as mounting tape reels. (3) The preparation of the system for normal operation.

short circuit. A low-resistance path through which current flows, rather than through a component or circuit.

signal. A variation of a physical quantity, used to convey data.

sink. A device or circuit into which current drains.

software. (1) Computer programs, procedures, and rules concerned with the operation of a data processing system. (2) Contrast with hardware.

source. The origin of a signal or electrical energy.

square wave. An alternating or pulsating current or voltage whose waveshape is square.

square wave generator. A signal generator delivering an output signal having a square waveform.

SS. Start-stop.

start bit. (1) A signal to a receiving mechanism to get ready to receive data or perform a function. (2) In a start-stop system, a signal preceding a character or block that prepares the receiving device for the reception of the code elements.

start-of-text (STX). A transmission control character that precedes a text and may be used to terminate the message heading.

start-stop system. A data transmission system in which each character is preceded by a start bit and is followed by a stop bit.

start-stop (SS) transmission. (1) Asynchronous transmission such that a group of signals representing a character is preceded by a start bit and followed by a stop bit. (2) Asynchronous transmission in which a group of bits is preceded by a start bit that prepares the receiving mechanism for the reception and registration of a character and is followed by at least one stop bit that enables the receiving mechanism to come to an idle condition pending the reception of the next character.

static memory. RAM using flip-flops as the memory elements. Data is retained as long as power is applied to the flip-flops. Contrast with dynamic memory.

stop bit. (1) A signal to a receiving mechanism to wait for the next signal. (2) In a start-stop system, a signal following a character or block that prepares the receiving device for the reception of a subsequent character or block.

storage. (1) A storage device. (2) A device, or part of a device, that can retain data. (3) The retention of data in a storage device. (4) The placement of data into a storage device.

strobe. An instrument that emits adjustable-rate flashes of light. Used to measure the speed of rotating or vibrating objects.

STX. Start-of-text.

symbol. (1) A conventional representation of a concept. (2) A representation of something by reason of relationship, association, or convention.

synchronization. The process of adjusting the corresponding significant instants of two signals to obtain the desired phase relationship between these instants.

Synchronous Data Link Control (SDLC). A protocol for management of data transfer over a data link.

synchronous transmission. (1) Data transmission in which the time of occurrence of each signal representing a bit is related to a fixed time frame. (2) Data transmission in which the sending and receiving devices are operating continuously at substantially the same frequency and are maintained, by means of correction, in a desired phase relationship.

syntax. (1) The relationship among characters or groups of characters, independent of their meanings or the manner of their interpretation and use. (2) The structure of expressions in a language. (3) The rules governing the structure of a language. (4) The relationships among symbols.

text. In ASCII and data communication, a sequence of characters treated as an entity if preceded and terminated by one STX and one ETX transmission control character, respectively.

time-out. (1) A parameter related to an enforced event designed to occur at the conclusion of a predetermined elapsed time. A time-out condition can be cancelled by the receipt of an appropriate time-out cancellation signal. (2) A time interval allotted for certain operations to occur; for example, response to polling or addressing before system operation is interrupted and must be restarted.

track. (1) The path or one of the set of paths, parallel to the reference edge on a data medium, associated with a single reading or writing component as the data medium moves past the component. (2) The portion of a moving data medium such as a drum, or disk, that is accessible to a given reading head position.

transistor-transistor logic (TTL). A popular logic circuit family that uses multiple-emitter transistors.

translate. To transform data from one language to another.

transmission. (1) The sending of data from one place for reception elsewhere. (2) In ASCII and data communication, a series of characters including headings and text. (3) The dispatching of a signal, message, or other form of intelligence by wire, radio, telephone, or other means. (4) One or more blocks or messages. For BSC and start-stop devices, a transmission is terminated by an EOT character. (5) Synonymous with data transmission.

TTL. Transistor-transistor logic.

V. Volt.

video. Computer data or graphics displayed on a cathode ray tube, monitor, or display.

volt. The basic practical unit of electric pressure. The potential that causes electrons to flow through a circuit.

W. Watt.

watt. The practical unit of electric power.

word. (1) A character string or a bit string considered as an entity. (2) See computer word.

write. To make a permanent or transient recording of data in a storage device or on a data medium.

write precompensation. The varying of the timing of the head current from the outer tracks to the inner tracks of the diskette to keep a constant 'write' signal.

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