MOS

MICROCOMPUTERS

TIM
TERMINAL INTERFACE MONITOR
MANUAL

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MICROCOMPUTER FAMILY

TIM MANUAL

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I. INTRODUCTION

TIM is the Terminal Interface Monitor program for MOS Technology's 65XX microprocessors. It is supplied in read-only memory (ROM) as part of the MCS6530-004 multi-function chip. Because the TIM code is nonvolatile, it is available at system power-on and cannot be destroyed inadvertently by user programs. Furthermore, the user is free to use only those TIM capabilities which he needs for a particular program. Both interrupt types, interrupt request (IRQ) and nonmaskable interrupt (NMI) may be set to transfer control to TIM or directly to the user's program.

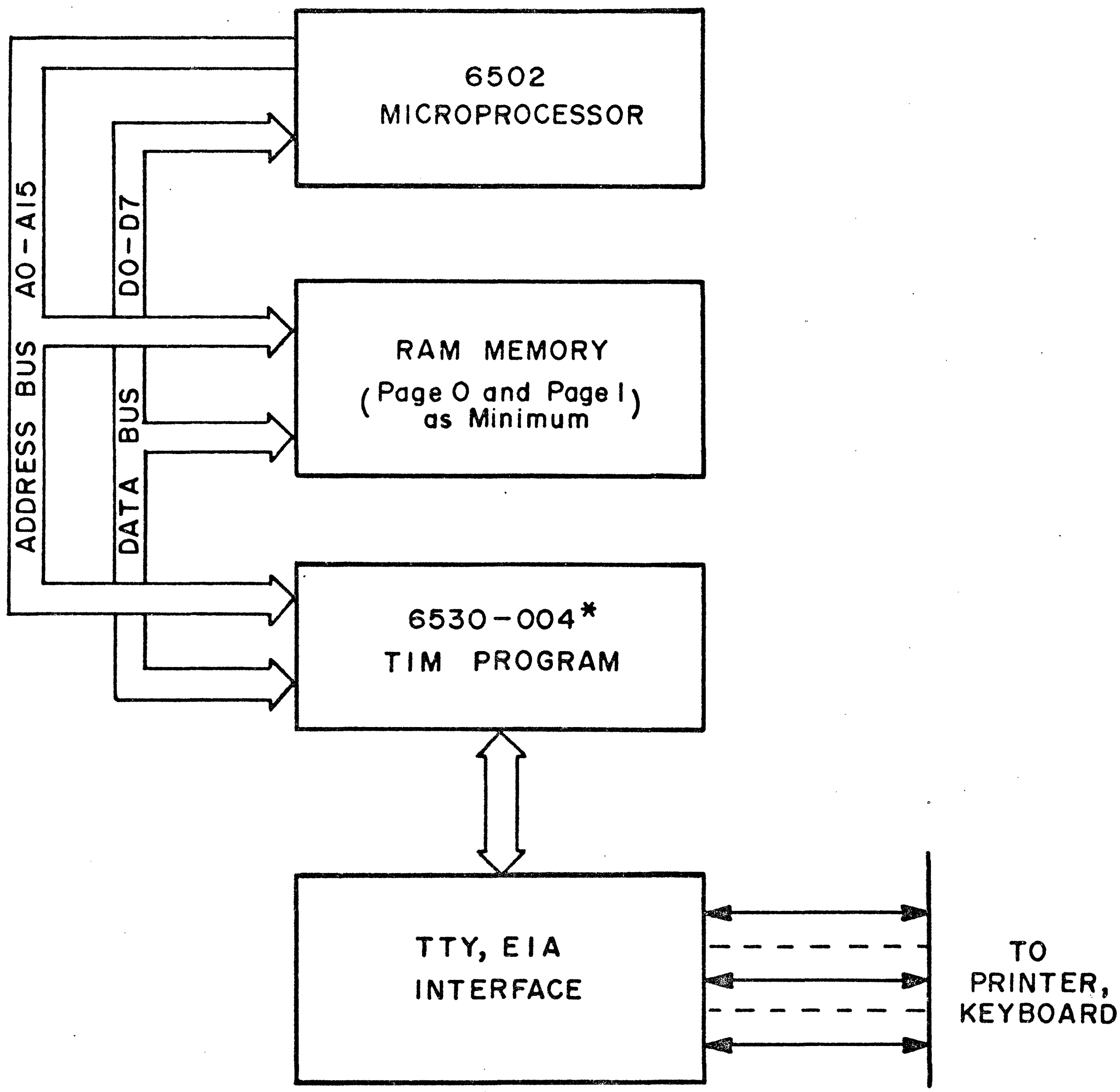
TIM communicates with the user via a serial full-duplex port (using ASCII codes) and automatically adjusts to the speed of the user's terminal. Any speed--even nonstandard ones--can be accommodated. If the user's terminal has a long carriage return time, TIM can be set to perform the proper delay. Commands typed at the terminal can direct TIM to start a program, display or alter registers and memory locations, set breakpoints, and load or punch programs. If available in the system configuration, a high-speed paper tape reader may be used to load programs through a parallel port on the MCS6530-004 chip. Programs may be punched in either of two formats--hexadecimal (assembler output) or BNPF (which is used for programming read-only memories). On loading or modifying memory, TIM performs automatic read-after-write verification to insure that addresses memory exists, is read/write type, and is responding correctly. Operator errors and certain hardware failures may thus be detected using TIM.

TIM also provides several subroutines which may be called by user programs. These include reading and writing characters on the terminal, typing a byte in hexadecimal, reading from high-speed paper tape, and typeing a carriage-return, line-feed sequence with proper delay for the carriage of the terminal being used. Program tapes loaded by TIM may also specify a start address so that programs may be started with a minimum of operator action.

II. SYSTEM CONFIGURATION

Since TIM is a "program" resident in the MCS6530-004 it must be properly configured in a proper system environment.

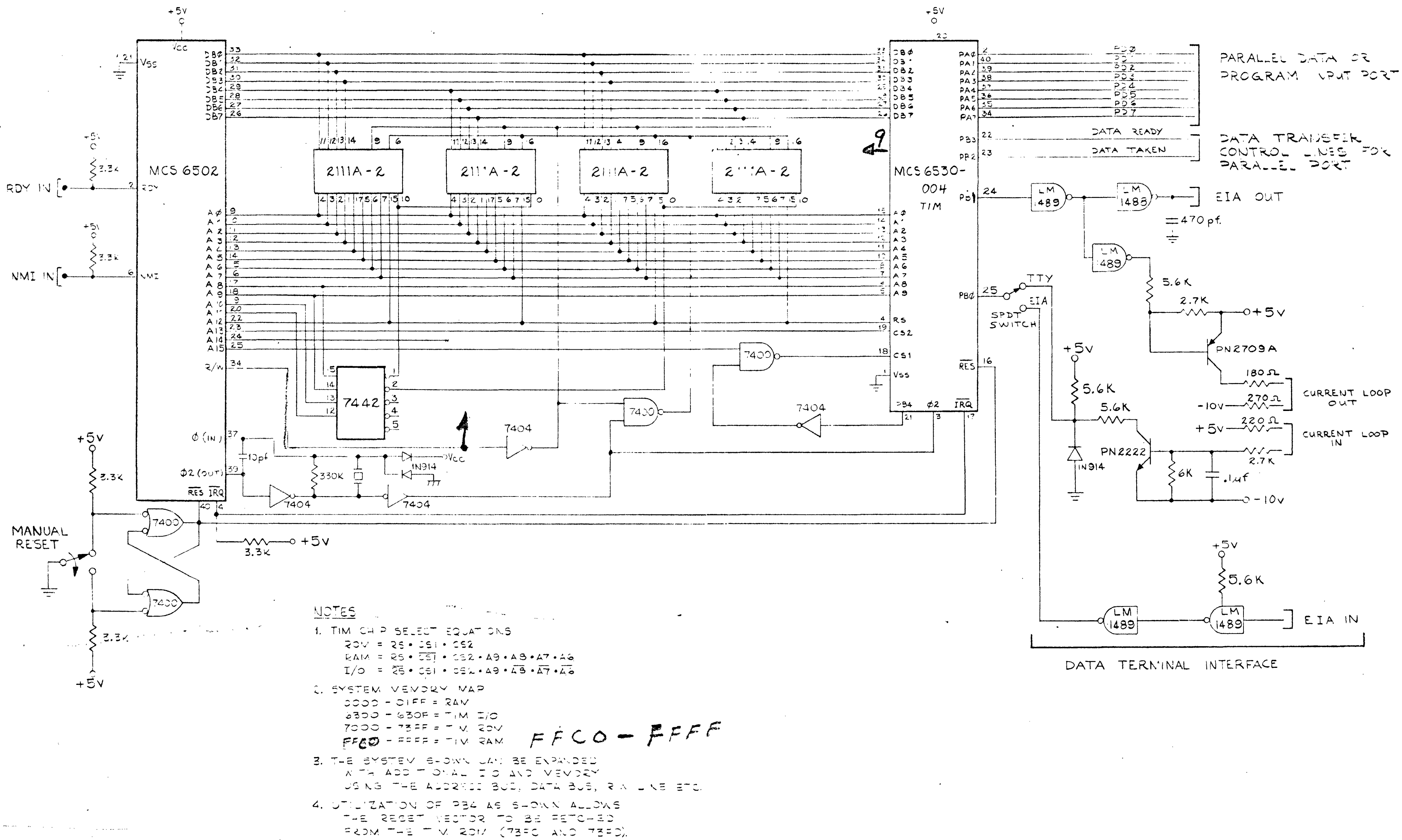
Figure 2-1 represents a block diagram of a minimum system utilizing the TIM program. The MCS6502 is the controlling microprocessor with two pages of memory (pages 0 and 1) representing the minimum RAM requirement. These devices, as well as a representative schematic for the TTY, EIA interfaces, are shown in Figure 2-2 which is a detailed system schematic utilizing the MCS6530-004. Note that the TIM function select equations are found on this schematic.



* Note that the TIM as sold consists only of the MCS6530-004 component accompanied by supporting information to build this system

TYPICAL MINIMUM CONFIGURATION
FOR "TIM" SYSTEM

FIGURE 2-1



"TIM" SYSTEM SCHEMATIC

FIGURE 2-2

III. OPERATIONAL FEATURES OF TIM

A. TIM Commands*

Command	Description
↴	Set line speed. After RESET, a carriage return is typed to allow TIM to measure the line speed.
.R	Display user registers. The format is: PC P A X Y S where: PC is the program counter P is the processor status A is the A (accumulator) register X is the X (index) register Y is the Y (index) register S is the stack pointer low byte (high byte is always 01)
.G	Go. Begin execution at user PC location (see R command).
.M addr	Memory examine. TIM will display the eight bytes beginning at address addr.
.: ADDR data	Alter registers or memory. TIM allows the user to alter registers (if R command precedes) or memory (if M command precedes). Values for registers or memory locations which are not to be changed need not be typed

* Characters typed by the user are underlined. All other characters are typed by the computer. ↴ means carriage-return.

—these fields may be skipped by typing spaces instead of data. The remainder of the fields in a line may be left unchanged by typing carriage return. The : command may be repeated to alter subsequent memory locations without the necessity of typing intervening M commands. Note that TIM automatically types spaces to separate data fields.

.LH

Load Hexadecimal. TIM responds with carriage return, line-feed and loads data in assembler output format from the terminal or high-speed paper tape reader. The format is:

Zero or more leading characters except ";" (usually blank leader)

Any number of records of the form:

;ccaaaadddd....ddssss

where:

cc is the number of bytes in the record in hex

aaaa is the hex address to store the first byte of data

dddd....dd is the data (two hex digits per byte)

ssss is the check-sum, which is the arithmetic sum, to 16 bits, of all the count, address and data bytes represented by the record

A terminating record of zero length, either: ;00 or ;↓

Note that read-after-write and check-sum tests are performed. An error will result in a "?" being typed at the point the error occurred. Data from records with bad check-sums is deposited in memory as received, prior to the error stop.

.H — High-speed/low-speed reader switch. This command switches the load device from the user's terminal to the high-speed reader or vice versa.

.WH addl addh↓ — Write Hexadecimal. An assembler-format tape is generated at the user's terminal. Format is as described above in the LH command description. Note that the address range must be specified with the lower address first. As in the Alter command, TIM types the space between the address fields.

.WB addl addh↓ — Write BNPF. A BNPF format tape is generated at the user's terminal. Format is one or more records as follows:

aaaa BddddddddF BddddddddF BddddddddF BddddddddF

where:

aaaa is the address of the first of the four bytes specified in the record. (Note: BNPF conventions require that the letter "B" never occur in the address field. Blanks are substituted by TIM.)

B is the letter "B", meaning begin data.

dddddddd is eight data bits—P for logical true, N for logical false.

F is the letter "F", meaning finish.

Note that the BNPF format is output as multiples of four bytes. Thus, a multiple of four bytes will always be punched even if a non-multiple of four bytes is specified.

Cancel Command. While typing any command, its further effect may normally be terminated by typing one or two carriage returns, as required. During alter (:), carriage return means that no further bytes (or registers) are to be altered.

B. TIM Interrupt and Breakpoint Action

BRK

The BRK instruction causes the CPU to interrupt execution, save PC and P registers on the stack. and branch through a vector at locations FFFE and FFFF. TIM initializes this vector to point to itself on RESET. Unless the user modifies this vector, TIM will gain control when a BRK instruction is executed, print an asterisk "*" and the registers (as in R command), and wait for user commands. Note that after a BRK which vectors to TIM, the user's PC points to the byte following the BRK; however, users who choose to handle BRK instructions themselves should note that BRK acts as a two-byte instruction, leaving the PC (on return via RTI) two bytes past the BRK instruction.

IRQ

Interrupt Request is also vectored through location FFFE. The CPU traps (as with BRK) through this vector when IRQ goes low, provided interrupts are not inhibited. Since this vector is the same as for BRK, TIM examines the BRK bit in the P register after this type of interrupt. If a BRK did not cause the interrupt, then TIM will pass control through the UINT vector. Users should normally put the address of their interrupt service routine in the UINT vector location. If an IRQ occurs and UINT has not been set by the user, TIM reports the unexpected interrupt in the same way as an NMI (see below).

NMI

Non-Maskable Interrupts vector through location FFFA. TIM initializes this vector at RESET to point to itself. If an NMI occurs, a pound-sign character (#) precedes the asterisk and CPU registers printout. This action is the same for IRQ's if the user has not set this vector to point to his own routine.

RESET or POWER-UP

On RESET or POWER-UP, TIM takes control, initializes itself and the system, sets defaults for interrupt vectors and waits for a carriage-return input from the user to determine terminal line speed. After carriage-return is typed, control is passed to the user as in BRK.

C. TIM Monitor Calls and Special Locations

Call	Address	Action	Arg.	Result	Notes
JSR WRT	72C6	Type a character	A	None	A,X cleared Y preserved
JSR RDT	72E9	Read a character	None	A	X cleared Y not preserved
JSR CRLF	728A	Type CR-LF and delay	None	None	A,X cleared Y preserved
JSR SPACE	7377	Type a space character	None	None	A,X,Y preserved
JSR WROB	72B1	Type a byte in hex	A	None	A,X cleared Y preserved
JSR RDHSR	733D	Read a character from high-speed paper tape reader	None	X—char read A—char trimmed to 7 bits	Y preserved

Function	Locations	Notes
Start Address	00F6,00F7	Set with hex tape on load
CR-LF Delay	00E3	Set on load or with user program (in bit times, minimum of 1. Zero means 256 bits-time delay).
UINT	FFF8	User IRQ vector
NMI Vector	FFFA	Hardware NMI vector
RESET Vector	FFFC	Hardware RESET vector
IRQ Vector	FFFE	Hardware IRQ vector

D. TIM Memory Usage

TIM uses the top 29_{10} bytes of page zero (locations 00E3 through 00FF). The user is advised to avoid these locations, except as noted above, if return to TIM or use of TIM subroutines is required before RESETing the processor. TIM also uses the hardware stack when it is in control. Provided the user does not alter the stack pointer during a break, and provided the stack does not overflow, TIM will restore the stack to its original status before returning to the user's program. The user is advised to use page 1 (the stack page) cautiously, leaving at least 20_{10} bytes for TIM use during a break or when using other TIM functions.

IV. TIM CHECKOUT PROCEDURE

The following step-by-step procedure assumes the user has built the TIM hardware system and is now ready to verify its functionality.

( ) 1. Turn power on, or if the power is on, perform a RESET operation. Type a carriage-return on the terminal. TIM should respond with:

```
* 7052  30  18  FF  01  FF
```

(Exact values may vary, although the first and last values should be as shown). If no response or a garbled response occurs, RESET and try again. In case of continued trouble, refer to the diagnostic section of the MOS Hardware Manual.

The "* 7052 30 18 FF 01 FF" printout is TIM's standard breakpoint message format. It consists of an asterisk "*" to identify the breakpoint printout, followed by the CPU register contents in this order: PC, P, A, X, Y, and S, i.e., Program Counter, Processor Status, Accumulator, X index, Y index and Stack Pointer. Note that all TIM inputs and outputs are in base 16 which is referred to as hexadecimal, or just hex. In hexadecimal, the "digits" are 0, 1, 2,..., A, B, C, D, E. F. After printing the CPU registers, TIM is ready to receive commands from you, the operator. TIM indicates this "ready" status by typing the prompting character "." on a new line.

( ) 2. TIM's response to RESET is to wait for a carriage-return and then print the user's registers. TIM uses this carriage-return character to measure the terminal line speed. If you have a settable-rate terminal, change the rate (any speed between 10 and 30 cps will work) and repeat Step 1. TIM should respond at the new terminal speed.

( ) 3. The user's CPU registers may also be displayed with the R command. Type an R. The monitor should respond as above, but without the asterisk. Presence of the asterisk indicates that an interrupt or break instruction caused the printout.

```
.R  7052  30  18  FF  01  FF
```

( ) 4. Displayed values may be modified using the Alter (:) command. To modify register contents, type a colon (:) followed by the new values. For example:

```
.R  7052  30  18  FF  01  FF
.:  0100  00  00  00  00  FF
.R  0100  00  00  00  00  FF
```

Notice that TIM automatically types spaces to separate data fields. (Note: Characters typed by you, the user, are underlined in this document for clarity. Everything else is typed by the computer.) Examine your registers (R command) to verify the changes.

Memory may be examined and modified, as above, using the M and : commands. Try this:

```
.M  0100  00  66  23  EE  01  A2  41  6E
```

The memory command (M) causes TIM to type the contents of the first eight bytes of memory. (Memory data will be random on startup). Alter and verify these bytes using the Alter command, as above:

```
.M    0100  00  66  23  EE  01  A2  41  6E
.:    0100  00  01  02  03  04  05  06  07
```

If only part of a line is to be altered, items to be left unchanged can be skipped over by typing blanks, and carriage-return (↓). Try this:

```
.M    0100  00  01  02  03  04  05  06  07
.:    0100  FF  __  FF  FF  ↓
.M    0100  FF  01  FF  FF  04  05  06  07
```

( ) 5. Try to alter a location in TIM ROM:

```
.M    7000  85  F9  A9  23  D0  58  A9  16
.:    7000  00?
```

TIM verifies all changes to memory. Since locations 7000 through 7007 are in read-only memory, alteration is not possible. TIM signals write failure with a question mark. Similarly, the monitor will notify you of an attempt to alter a non-existant location:

```
.M    9000  90  90  90  90  90  90  90  90
.:    9000  00?
```

Note that attempts to <u>read</u> non-existant memory will normally yield the high-order byte of the address read.

( ) 6. There are three hardware facilities which may be used to stop a running (or run-away) program without the program itself calling TIM . These are the hardware inputs RESET, IRQ, and NMI. To test this feature enter the following program at location 0000:

location	contents	instruction
0000	4C	LOOP JMP LOOP
0001	00	
0002	00	

(Use the M and : commands.)

Now, set the program counter (PC) to this location using the R and : commands. Finally, tell TIM to start executing your program using the Go (G) command:

```
.M  0000  FF  11  11  11  91  91  71  91
.:  0000  4C  00  00  ↓
.M  0000  4C  00  00  11  91  91  71  91
.R  0000  30  00  00  00  FF
.:  0000  ↓
.G
```

The computer should now be executing the program. It will continue to run until interrupted. Using the interrupt request line (IRQ), interrupt the processor. It should respond with:

```
*  0000  30  00  00  00  FF
```

Try the same experiment with non-maskable interrupt (NMI). The result should be the same except for a "#" character preceeding, which identifies the NMI printout. Finally, try it with RESET. RESET, however, forces a CPU branch to TIM, losing the old PC and other register contents. Thus NMI is the preferred means for manually interrupting program execution. IRQ may also be used unless it is required for other functions such as peripheral interrupts.

( ) 7. Use M and : to enter the following test program called CHSET because it prints the character-set on the terminal. Note that Alter (:) commands may be repeated without intervening M commands to set sequential locations:

```
                        ;CHECKOUT PRCGRAM -- PRINT THE CHARACTER SET CN USER TERMINAL

                        CRLF    =$728A          ;ACCRESS CF  TIM  CRLF ROUTINE
                        WRT     =$72C6          ;ADDRESS CF  TIM  WRITE RCUTINE
                        ;
CC                              *=C             ;VARIABLE STCRAGE IN PAGE ZERO
CC0C                    CHAR    *=*+1           ;STORAGE FOR CHARACTER
                        ;
0001                            *=$01C0         ;PRCGRAM STARTS CN PAGE CNE
                        ;
0100  2C 8A 72          CHSET   JSR CRLF        ;DC CARRIAGE RETURN & LINE FEEC
0103  A9 20                     LDA #$20        ;FIRST CHAR IS A SPACE
C1C5  85 CC                     STA CHAR        ;INITIALIZE
                        ;
0107  A5 00             LCCP    LDA CHAR        ;GET CHARACTER
C1C9  C9 6C                     CMP #$6C        ;CHECK FCR LIMIT
010B  FO C8                     BEQ CONE        ;DONE IF 60
                        ;
C1CD  2C C6 72                  JSR WRT         ;PRINT CHAR
0110  E6 CC                     INC CHAR        ;NEXT CHAR CCDE
0112  4C C7 C1                  JMP LCCP        ;CCNTINUE
                        ;
0115  CC                DONE    BRK             ;STOP & RETURN TO  TIM  MCNITCR
                        ;
0116  4C CC C1                  JMP CHSET       ;DC IT AGAIN
```

```
.M   0100  20  8D  72  20  EC  72  8D  26
.:   0100  20  8A  72  A9  20  85  00  A5
.:   0108  00  C9  60  F0  08  20  C6  72
.:   0110  E6  00  4C  07  01  00  4C  00
.:   0118  01  ↓
```

Now run the program. Do this by setting the PC to 0100 and using the G command. The listing should look like this:

```
.R  0000 30 00 00 00 FF
.:  0100 ↓
.G
 !"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑←
 *  0116 33 60 00 00 FF
```

The program may be continued, causing it to execute again, by typing G:

```
.G
 !"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑←
 *  0116 33 60 00 00 FF
.G
 !"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑←
 *  0116 33 60 00 00 FF
.G
 !"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]↑←
 *  0116 33 60 00 00 FF
```

The CHSET program uses two TIM monitor functions: CRLF is the TIM function which causes a carriage-return and line-feed to be typed on the terminal. WRT is the routine which prints the character whose code is in the A register at the time of the call.

( ) 8. Save the CHSET program on paper tape (if your terminal has a punch) as follows: First, punch some leader tape with the terminal in local mode. Then return to line mode and enter:

.WH 0100 0118 ↵

Turn the punch on after typing the second address, but before typing carriage-return. Then type carriage-return to punch the tape. When punching stops, turn the terminal back to local and type:

;00

and some blank trailer. This is a zero-length record which terminates your tape. See Appendix II for more information on tape formats.

( ) 9. Try re-loading your program using the LH command:

.LH

Now start the reader to load the program. The tape will be read and printed simultaneously. Stop the tape when the end is reached. (Before loading, you may wish to destroy the program in memory to verify that loading from tape actually works.)

( ) 10. Use the M and : commands to load the following program:

```
                ;CHECKOUT PROGRAM -- PRINT BINARY OF TYPED CHARACTER
                ;

                ;
0000            .        *=0           ;VARIABLE STORAGE IN PAGE ZERO
0000            BINARY   *=*+1         ;STORAGE FOR CHAR DURING DISSECTION
0001            COUNT    *=*+1         ;COUNT OF BITS REMAINING TO PRINT
                ;
0002                     *=$0100       ;PROGRAM BEGINS ON PAGE ONE
                ;
                CRLF     =$728A         ;TIM  CRLF ROUTINE
                WRT      =$72C6         ;TIM  WRITE ROUTINE
                RDT      =$72E9         ;TIM  READ ROUTINE
                SPACE    =$7377         ;TIM  SPACE ROUTINE
                ;
0100  20 8A 72  PBIN     JSR CRLF      ;PRINT CARRIAGE RETURN & LINE FEED
0103  20 E9 72           JSR RDT       ;GET A CHARACTER
0106  85 00              STA BINARY    ;SAVE FOR DISSECTION
0108  20 77 73           JSR SPACE     ;PRINT A SPACE
                ;
010B  A9 08              LDA #8        ;INITIALIZE BIT COUNT
010D  85 01              STA COUNT
                ;
010F  A9 30     PBLOOP   LDA #'0       ;ASSUME ZERO: LOAD ASCII "0"
0111  06 00              ASL BINARY    ;C=NEXT BIT
0113  B0 02              BCS PRINT     ;PRINT ZERO
                ;
0115  A9 31              LDA #'1       ;LOAD ASCII "1"
                ;
0117  20 C6 72  PRINT    JSR WRT       ;PRINT BINARY DIGIT
011A  C6 01              DEC COUNT     ;COUNT BIT PRINTED
011C  10 F1              BPL PBLOOP    ;DO NEXT BIT
                ;
011E  4C 00 01           JMP PBIN      ;DO IT ALL AGAIN
```

```
.M   0100  20  8D  72  A9  20  85  00  A5
.:   0100  20  8A  72  20  E9  72  85  00
.:   0108  20  77  73  A9  08  85  01  A9
.:   0110  30  06  00  B0  02  A9  31  20
.:   0118  C6  72  C6  01  10  F1  4C  00
.:   0120  01  ↓
```

The purpose of this program is to print the binary representation of an ASCII input character on the terminal. Run the program by starting it at location 0100. Try typing some characters:

```
.R    0116  33  60  00  00  FF
.:    0100  ↓
.G
U  101010101
B  101111011
1  110011101
```

There is obviously something wrong with the program. Bits which should be printed as 1's are 0's and vice versa. (Refer to your 6500 reference card for character codes.) Looking at the program, the problem is that the branch after PBLOOP goes the wrong way! It should be BCC, Branch if Carry Clear (or alternatively, the 1 and 0 loads could be interchanged). Thus, when a one-bit is shifted out of the character, a one should be printed.

Patch the program and try again (the code for BCC is 90).

```
.M    0113  B0  02  A9  31  20  C9  72  C6
.:    0113  90  ⤵
.R    7052  31  FC  FF  01  FF
.:    0100  ⤵
.G
U  010101010
B  010000100
1  001100010
```

There is, alas, still an error--one too many bits is being printed. The cause of this is a little less obvious. (Do you see it?) To investigate the problem, set a breakpoint at location 011E. Do this by replacing the instruction there with a BRK (code of 00). Then run the program:

```
.M    011E  4C  00  01  EF  4C  00  01  00
.:    011E  00  ⤵
.R    7052  31  FC  FF  01  FF
.:    0100  ⤵
.G
U  010101010
 *    011F  B0  00  00  AA  FF
```

Once the break has occurred, you are free to investigate the state of the program using TIM. In particular, check the value in location COUNT:

```
.M    0000  00  FF  1B  2E  31  EA  FO  FA
```

Aha! Although COUNT starts out with a value of 8, it is going one step too far (FF is minus 1). This is because the test instruction, BPL PBLOOP is testing to see whether the count is greater than or equal to zero. Replace it with BNE (code D0), replace your breakpoint with the original contents at that location, and try the program again.

```
.M  011C  10  F1 00  00  01  EF  4C
.:  011C  D0  __ 4C  ↓
.R  011F  B0  00 00  AA  FF
.:  0100  ↓
.G
U  01010101
B  01000010
1  00110001
I  01001001
W  01010111
O  01001111
R  01010010
K  01001011
S  01010011
```

```
                    ;CHECKOUT PROGRAM -- PRINT BINARY OF TYPED CHARACTER
                    ;
                    ;
0000                        *=0              ;VARIABLE STORAGE IN PAGE ZERO
0000                BINARY  *=*+1            ;STORAGE FOR CHAR DURING DISSECTION
0001                COUNT   *=*+1            ;COUNT OF BITS REMAINING TO PRINT
                    ;
0002                        *=$0100          ;PROGRAM BEGINS ON PAGE ONE
                    ;
                    CRLF    =$728A           ;TIM  CRLF ROUTINE
                    WRT     =$72C6           ;TIM  WRITE ROUTINE
                    RDT     =$72E9           ;TIM  READ ROUTINE
                    SPACE   =$7377           ;TIM  SPACE ROUTINE
                    ;
0100  20 8A 72      PBIN    JSR CRLF         ;PRINT CARRIAGE RETURN & LINE FEED
0103  20 E9 72              JSR RDT          ;GET A CHARACTER
0106  85 00                 STA BINARY       ;SAVE FOR DISSECTION
0108  20 77 73              JSR SPACE        ;PRINT A SPACE
                    ;
010B  A9 08                 LDA #8           ;INITIALIZE BIT COUNT
010D  85 01                 STA COUNT
                    ;
010F  A9 30         PBLOOP  LDA #'0          ;ASSUME ZERO: LOAD ASCII "0"
0111  06 00                 ASL BINARY       ;C=NEXT BIT
0113  90 02                 BCC PRINT        ;PRINT ZERO
                    ;
0115  A9 31                 LDA #'1          ;LOAD ASCII "1"
                    ;
0117  20 C6 72      PRINT   JSR WRT          ;PRINT BINARY DIGIT
011A  C6 01                 DEC COUNT        ;COUNT BIT PRINTED
011C  D0 F1                 BNE PBLOOP       ;DO NEXT BIT
                    ;
011E  4C 00 01              JMP PBIN         ;DO IT ALL AGAIN
```

CORRECTED PBIN PROGRAM

( ) 11. Save the corrected program using the WH command. Before punching the terminating record (as above in step 8), turn off the punch and set the PC to the start address of the program (0100). Then punch locátions 00F6 and 00F7 on the tape, then the terminator (;00), and finally, some trailer:

```
.R    7052  30  37  FF  01  FF
.:    0100  ↓
.WH   00F6  00F7  ↓
;0200F6000101A2
.;00
```

The resulting tape can be loaded and then started as follows:

```
.LH
 :  (program loads in)
 :
.G
```

Locations 00F6 and 00F7 contain the starting address for programs. You may assemble and load your starting address into these locations to make tapes which can be started with a minimum of operator action. The carriage-return delay time may also be set in this manner. See Appendix II.

( ) 12. It is also possible to punch BNPF-format tapes using TIM. BNPF is the format used by some ROM programmers. The command is similar to that for writing hex tapes:

```
.WB  0100  0127  ↓
```

This command would punch the corrected PBIN program in BNPF format. Try punching a BNPF tape. (Note that TIM will <u>not</u> load tapes in this format--use hex format (WH) for saving programs for later loading into your 65XX.)

( ) 13. If you have a high-speed paper tape reader attached to your 65XX system, you can use it to load programs in hex format. The H command switches the load device to and from the high speed reader. If you have a high speed reader, try loading a tape as follows:

.H
.LH

Note that control will not return to the user terminal until a terminator record (;00) is read.

APPENDIX A

MEMORY ADDRESS TEST

```
LOC     CODE        CARD
                    ;MEMORY ADDRESS TEST
                    ;FOR EACH LOC IN TEST RANGE
                            ;CLEAR WHOLE RANGE
                    ;       SET LOC TO $FF
                    ;       VERIFY WHOLE RAGE $00 EXCEPT (LOC)
                    ;       VERIFY (LOC) TO BE $FF
                    ;BREAK TO MONITOR ON ERROR WITH LOC IN (0,1)
                    ;PRINT "*" ON COMPLETION OF PASS & REPEAT
                    ;
0000                        *=$0000             ;PAGE 0
                    ;
                    WRT     =$72C2
0000                LOC     *=*+2               ;TEST CELL ADDR
0002                LOW     *=*+2               ;LOWER LIMIT OF TEST
0004                HIGH    *=*+2               ;UPPER LIMIT OF TEST+1
0006                PTR     *=*+2               ;POINTER TO CELL UNDER TEST
                    ;
0008                        *=$0010             ;START ADDR
                    ;
0010    A9 0D       MAD     LDA #$0D            ;TYPE CR
0012    20 C2 72            JSR WRT
0015    A9 0A               LDA #$0A            ;& LF
0017    20 C2 72            JSR WRT
                    ;
001A    20 68 00            JSR RSTLOC          ;LOC=LOW

001D    20 71 00            JSR RSTPTR          ;PTR=LOW

0020    A2 00               LDX #0
                    ;
                    ;CLEAR MEMORY AREA UNDER TEST
0022    A9 00       ML1     LDA #0
0024    81 06               STA (PTR,X)         ;STORE ZERO
0026    20 7A 00            JSR INCPTR          ;INCREMENT & TEST

0029    D0 F7               BNE ML1             ;NEXT LOC
                    ;
                    ;PUT $FF IN SELEXTED CELL
002B    A9 FF       TEST    LDA #$FF
002D    81 00               STA (LOC,X)
                    ;VERIFY ALL CELLS ZERO EXCEPT (LOC)
002F    20 71 00            JSR RSTPTR          ;PTR=LOW

                    ;
0032    A1 06       VLOOP   LDA (PTR,X)         ;GET CELL
0034    F0 17               BEQ NEXTC           ;CK IF ZERO
0036    A4 06               LDY PTR             ;NOT ZERO--IS THIS (LOC)?
0038    C4 00               CPY LOC
003A    F0 01               BEQ OK1
003C    00                  BRK                 ;NOT (LOC)
                    ;
003D    A4 07       OK1     LDY PTR+1
```

```
CARD # LOC     CODE          CARD
       003F    C4 01                CPY LOC+1
       0041    F0 01                BEQ CK2
       0042    00                   BRK                ;NOT (LOC)
                             ;
       0044    C9 FF         CK2    CMP #$FF           ;IS (LOC)--IS DATA OK?
       0046    F0 01                BEQ OK3
       0048    00                   BRK                ;WRONG DATA
                             ;
       0049    A9 00         OK3    LDA #0             ;RESET (LOC)
       004B    81 00                STA (LOC,X)
                             ;
       004D    20 7A 00      NEXTC  JSR INCPTR         ;NEXT CELL

       0050    D0 E0                BNE VLOOP          ,IF NOT AT LIMIT
                             ;
       0052    A5 00                LDA LOC            ;PRINT STAR EVERY PAGE BOUNDA
       0054    D0 07                BNE NOSTAR
       0056    A9 2A                LDA #'*
       0058    20 C2 72             JSR WRT
       005B    A2 00                LDX #0             ;FIX X AFTER MON CALL
                             ;
       005D    20 8B 00      NOSTAR JSR INCLOC         ;NEXT LOC

       0060    D0 C9                BNE TEST
                             ;
       0062    20 68 00             JSR RSTLOC         ;PASS COMPLETE

       0065    4C 10 00             JMP MAD            ;NEXT PASS
                             ;
                             ;RESET LOC TO LOW
       0068    A5 02         RSTLOC LDA LOW
       006A    85 00                STA LOC
       006C    A5 03                LDA LOW+1
       006E    85 01                STA LOC+1
       0070    60                   RTS
                             ;
                             ;RESET PTR TO LOW
       0071    A5 02         RSTPTR LDA LOW
       0073    85 06                STA PTR
       0075    A5 03                LDA LOW+1
       0077    85 07                STA PTR+1
       0079    60                   RTS
                             ;
                             ;INCREMENT PTR & CHECK FOR LIMIT
       007A    E6 06         INCPTR INC PTR            ;INCREMENT
       007C    D0 02                BNE INC1
                             ;
       007E    E6 07                INC PTR+1
                             ;
       0080    A5 04         INC1   LDA HIGH           ;CHECK
       0082    C5 06                CMP PTR
       0084    D0 04                BNE IPRET          ;NOT AT LIMIT
```

```
CARD # LOC      CODE        CARD
  98                      ;
  99   0086  A5 05              LDA HIGH+1
 100   0088  C5 07              CMP PTR+1           ;Z=1 IF AT LIMIT
 101                      ;
 102   008A  60           IPRET  RTS
 103                      ;
 104                      ;INCREMENT LOC & CHECK FOR LIMIT
 105   008B  E6 00        INCLOC INC LOC            ;INCR
 106   008D  D0 02              BNE INC2
 107                      ;
 108   008F  E6 01              INC LOC+1
 109                      ;
 110   0091  A5 04        INC2   LDA HIGH           ;CHECK
 111   0093  C5 00              CMP LOC
 112   0095  D0 04              BNE ILRET
 113   0097  A5 05              LDA HIGH+1
 114   0099  C5 01              CMP LOC+1           ;Z=1 IF AT LIMIT
 115
 116   009B  60           ILRET  RTS


END OF MOS/TECHNOLOGY 6501 ASSEMBLY VERSION 3
NUMBER OF ERRORS =    0,  NUMBER OF WARNINGS =    0
```

SYMBOL TABLE

```
SYMBOL   VALUE  LINE DEFINED         CROSS-REFERENCES

HIGH     0004         15     95   99  110  113
ILRET    009B        116    112
INCLOC   008B        105     65
INCPTR   007A         90     32   60
INC1     008C         95     91
INC2     0091        110    106
IPRET    008A        102     97
LOC      0000         13     37   44    49    58    63    77    79   105   108   111
                            114
LOW      0002         14     76   78    83    85
MAD      001C         20     73
ML1      0022         30     33
NEXTO    004C         60     42
NOSTAR   005C         69     64
OK1      003C         48     45
OK2      0044         53     50
OK3      0049         57     54
PTR      0006         16     31   41    43    48    84    86    90    93    96   100
RSTLOC   006E         76     25   72
RSTPTR   0071         83     26   39
TEST     0028         36     70
VLOOP    0032         41     61
WRT      72C2         12     21   23    66
```

APPENDIX B

TIM PROGRAM LISTINGS

```
CARD # LOC      CODE        CARD
                            ;
                            ;      MOS TECHNOLOGY 650X TERMINAL INTERFACE MONITOR (TIM)
                            ;             VERSION 1.0  AUGUST 31, 1975
                            ;             COPYRIGHT 1975 MOS TECHNOLOGY
                            ;             ALL RIGHTS RESERVED.  UNAUTHORIZED USE
                            ;             OF ALL OR PART STRICTLY PROHIBITED.
                            ; - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                            ;
                            ; PROMPTING CHARACTER IS A PERIOD (.)
                            ; -----------------------------------
                            ;
                            ;
                            ; DISPLAY COMMANDS
                            ; ----------------
                            ;
                            ; .R            DISPLAY REGISTERS (PC,F,A,X,Y,SP)
                            ; .M  ADDR      DISPLAY MEMORY ( 8 BYTES BEGINNING AT ADDR )
                            ;
                            ;
                            ; ALTER COMMAND (:)
                            ; -----------------
                            ; .:  DATA      ALTERS PREVIOUSLY DISPLAYED ITEM OR NEXT ITEM
                            ;
                            ;
                            ; PAPER TAPE I/O COMMANDS
                            ; ------------------------
                            ;
                            ; .LH                     LOAD HEX TAPE
                            ; .WB ADDR1 ADDR2         WRITE BNPF TAPE (FROM LOW ADDR1 TO HIGH ADDR2)
                            ; .WH ADDR1 ADDR2         WRITE HEX TAPE (FROM LOW ADDR1 TO HIGH ADDR2)
                            ;
                            ; CONTROL COMMANDS
                            ; ----------------
                            ;
                            ; .G                      GO, CONTINUE EXECUTION FROM CURRENT PC ADDRESS
                            ;
                            ; .H                      TOGGLES HIGH-SPEED-READER OPTION
                            ;                           (IF ITS ON, TURNS IT OFF; IF OFF, TURNS ON
                            ;
                            ; BRK AND NMI ENTRY POINTS TO TIM
                            ; -------------------------------
                            ;
                            ;     TIM IS NORMALLY ENTERED WHEN A 'BRK' INSTRUCTION IS
                            ;         ENCOUNTERED DURING PROGRAM EXECUTION.  AT THAT
                            ;         TIME CPU REGISTERS ARE OUTPUT:   PC F A X Y SP
                            ;         AND CONTROL IS GIVEN TO THE KEYBOARD.
                            ;     USER MAY ENTER TIM BY PROGRAMMED BRK OR INDUCED NMI.  NMI
                            ;         ENTRIES CAUSE A '#' TO PRECEDE THE '*' IN THE CPU REGISTER
                            ;         PRINTOUT FORMAT
                            ;
                            ; NON-BRK INTRQ (EXTERNAL DEVICE) INTERRUPT HANDLING
                            ; --------------------------------------------------
```

```
CARD # LOC      CODE        CARD
                            ;
                            ;      A NON-BRK INTRQ INTERRUPT CAUSES AN INDIRECT JUMP TO THE ADDRESS
                            ;          LOCATED AT 'UINT' (HEX FFF8).  THIS LOCATION CAN BE SET
                            ;          USING THE ALTER CMD, OR LOADED AUTOMATICALLY IN PAPER TAPE
                            ;          FORM WITH THE LH CMD IF THE USER ASSIGNS HIS INTRQ INTERRUPT
                            ;          VECTOR TO $FFF8 IN THE SOURCE ASSEMBLY PROGRAM.
                            ;      IF NOT RESET BY THE USER, UINT IS SET TO CAUSE EXTERNAL
                            ;          DEVICE INTERRUPTS TO ENTER TIM AS NMI'S.  I.E.,
                            ;          IF A NMI OCCURS WITHOUT AN INDUCED NMI SIGNAL, IT IS
                            ;          AN EXTERNAL DEVICE INTERRUPT.
                            ;
                            ;  SETTING AND RESETTING PROGRAM BREAKPOINTS
                            ;  -----------------------------------------
                            ;
                            ;      BREAKPOINTS ARE SET AND RESET USING THE MEMORY DISPLAY
                            ;          AND ALTER COMMANDS.  BRK HAS A '00' OPERATION CODE.
                            ;      TO SET A BREAKPOINT SIMPLY DISPLAY THE MEMORY LOCATION
                            ;          (FIRST INSTRUCTION BYTE) AT WHICH THE BREAKPOINT IS
                            ;          TO BE PLACED THEN ALTER THE LOCATION TO '00'.  THERE IS
                            ;          NO LIMIT TO THE NUMBER OF BREAKPOINTS THAT CAN BE
                            ;          ACTIVE AT ONE TIME.
                            ;      TO RESET A BREAKPOINT, RESTORE THE ALTERED MEMORY LOCATION
                            ;          TO ITS ORIGINAL VALUE.
                            ;      WHEN AND IF A BREAKPOINT IS ENCOUNTERED DURING EXECTUION,
                            ;          THE BREAKPOINT DATA PRECEDED BY AN '*' IS DISPLAYED.
                            ;          THE PROGRAM COUNTER VALUE DISPLAYED IS THE BRK
                            ;          INSTRUCTION LOCATION + 1.
                            ;
                            ;  ---------------------------------------------------------------
                            ;
                            MDBK   =%00001011C          ; X,X,X,POR,DATA-AVAIL,GOT-DATA,SERIAL-OUT,IN
                            DAVAIL =$08
                            GOTDAT =$04
                            IOBASE =$6E00
                            MPA    =IOBASE+0
                            MDA    =IOBASE+1
                            MPB    =IOBASE+2
                            MDB    =IOBASE+3
                            MCLKIT =IOBASE+4
                            MCLKRD =IOBASE+4
                            MCLKIF =IOBASE+5
                            UINT   =$FFF8
                            NCMDS  =7
                            MP0    =$7000
                            MP1    =$7100
                            MP2    =$7200
                            MP3    =$7300
                            ;
                            ;  ZERO PAGE MONITOR RESERVE AREA
                            ;
                            CRDLY  =227                 ;DELAY FOR CR IN BIT-TIMES
                            WRAP   =228                 ;ADDRESS WRAP-AROUND FLAG
```

TIM VERSION 1.0 - MEM PAGE 0

```
CARD # LOC      CODE      CARD
 106                      DIFF    =229
 107                      HSPTR   =231
 108                      HSPCP   =232
 109                      PREVC   =233
 110                      MAJORT  =234
 111                      MINORT  =235
 112                      ACMD    =236
 113                      TMP0    =238
 114                      TMP2    =240
 115                      TMP4    =242
 116                      TMP6    =244
 117                      PCL     =246
 118                      PCH     =247
 119                      FLGS    =248
 120                      ACC     =249
 121                      XR      =250
 122                      YR      =251
 123                      SP      =252
 124                      SAVX    =253
 125                      TMPC    =254
 126                      TMPC2   =255
 127                      RCNT    =TMPC
 128                      LCNT    =TMPC2
 129                      ;
 130                      ;  64 BYTE RAM MONITER RESERVE AREA
 131                      ;
 132                      RAM64   =$FFC0
 133  0000                        *=RAM64
```

```
LOC     CODE          CARD
                      ;
                      ;
                      ;   TIM PAGE 0 (RELATIVE)
FFC0                        *=MPO
                      ;
7000    85 F9         NMINT   STA ACC           ; SAVE A
7002    A9 23                 LDA #'#           ; SET A=# TO INDICATE NMINT ENTRY
7004    DC 55                 BNE B3            ; JMP B3
                      ;
7006    A9 16         RESET   LDA #MDBK         ; INIT DIR REG, PCR TO 1 RELOCATES
                      ;
7008    8D Ø3 6E              STA MDB
                      ;
700B    A2 Ø8                 LDX #8            ; X=0
700D    BD F7 73      R1      LDA INTVEC-1,X    ; INITIALIZE INT VECTORS
7010    9D F7 FF              STA UINT-1,X
7013    CA                    DEX
7014    D0 F7                 BNE R1
                      ;
7016    86 EA                 STX MAJORT        ; INIT MAJOR T COUNT TO ZERO
7018    86 E7                 STX HSPTR         ; CLEAR HSPTR FLAGS
701A    86 E8                 STX HSRCP
701C    CA                    DEX               ; X=FF
701D    9A                    TXS               ; SP=FF
                      ;
                      ;                         ; COMPUTE BIT-TIME CONSTANT, X=FF
                      ;
701E    A0 01                 LDY #1            ; SET TO MEASURE 2 BITS
7020    84 E3                 STY CRDLY         ;INIT CR DELAY TIME PARAMETER
7022    AD Ø2 6E      R0      LDA MPB           ; WAIT FOR START
7025    4A                    LSR A
7026    90 FA                 BCC R0
                      ;
7028    8E 04 6E      R2      STX MCLK1T        ; START CLOCK INITIALLY WITH FF
702B    AD 05 6E      R3      LDA MCLKIF
702E    10 Ø4                 BPL R4
7030    E6 EA                 INC MAJORT        ; COUNT MAJOR T
7032    DØ F4                 BNE R2            ; GO RESTART CLOCK WITH X = FF
                      ;
7034    98            R4      TYA
7035    4D 02 6E              EOR MPB
7038    29 01                 AND #1
703A    F0 EF                 BEQ R3            ; WAIT FOR Y BIT 0 AND SERIAL-IN NOT EQU
703C    88                    DEY
703D    10 EC                 BPL R3            ; LOOP UNTIL START OF BIT 2
                      ;
703F    AD 04 6E              LDA MCLKRD
7042    49 FF                 EOR #$FF          ; COMPLEMENT RESIDUE
7044    4A            R5      LSR A             ; HALF  T
7045    46 EA                 LSR MAJORT        ; HALF MAJOR
7047    90 02                 BCC R6
7049    09 80                 ORA #$80          ; PROPAGATE HO TO LO
```

```
CARD # LOC      CODE         CARD
       7C4B  C8          R6       INY
       7C4C  FC F6                BEQ R5
       704E  85 EB                STA MINORT
                         ;
       7050  58                   CLI                 ; ENABLE INTS
       7C51  CC                   BRK                 ; ENTER TIM BY BRK
                         ;
       7052  85 F9       INTRQ    STA ACC             ; SAVE ACC
       7C54  68                   PLA                 ; FLAGS TO A
       7055  48                   PHA                 ; RESTORE STACK STATUS
       7C56  29 10                AND #$10            ; TEST BRK FLAG
       7C58  FC 27                BEQ BX              ; USER INTERRUPT
                         ;
       7C5A  CA                   ASL A               ; SET A=SPACE (10 X 2 = 20)
       7C5B  85 FE       B3       STA TMPC            ; SAVE INT TYPE FLAG
       705C  D8                   CLD                 ; CLEAR DECIMAL MODE
       7C5E  4A                   LSR A               ; # IS ODD, SPACE IS EVEN
                                                      ; SET CY FOR PC BRK CORRECTION
                         ;
       7C5F  86 FA                STX XR              ; SAVE X
       7C61  84 FB                STY YR              ; Y
       7C63  68                   PLA
       7C64  85 F8                STA FLGS            ; FLAGS
       7066  68                   PLA
       7C67  69 FF                ADC #$FF            ; CY SET TO PC-1 FOR BRK
       7C69  85 F6                STA PCL
       706B  68                   PLA
       7C6C  69 FF                ADC #$FF
       7C6E  85 F7                STA PCH
       7C7C  BA                   TSX
       7C71  86 FC                STX SP              ; SAVE ORIG SP
                         ;
       7C73  2C 8A 72    B5       JSR CRLF
       7C76  A6 FE                LDX TMPC
                         ;
       7C78  A9 2A                LDA #'*
       7C7A  2C CC 72             JSR WRTWO
       7C7D  A9 52                LDA #'R             ; SET FOR R DISPLAY TO PERMIT
       7C7F  DC 16                BNE SO              ;   IMMEDIATE ALTER FOLLOWING BREAKPOINT.
                         ;
       7C81  A5 F9       BX       LDA ACC
       7C83  6C F8 FF             JMP (UINT)          ; CONTROL TO USER INTRQ SERVICE ROUTINE
                         ;
       7C86  A9 00       START    LDA #0              ;NEXT COMMAND FROM USER
       7C88  85 E7                STA HSPTR           ;CLEAR H. S. PAPER TAPE FLAG
       708A  85 F4                STA WRAP            ;CLEAR ADDRESS WRAP-AROUND FLAG
       7C8C  2C 8A 72             JSR CRLF
       708F  A9 2E                LDA #'.             ; TYPE PROMPTING '.'
       7C91  2C C6 72             JSR WRTT
       7C94  20 E9 72             JSR RDOC            ; READ CMD, CHAR RETURNED IN A
                         ;
       7C97  A2 C6       SO       LDX #NCMDS-1        ; LOOK-UP CMD
```

```
LOC     CODE          CARD
7099  DD 06 71  S1      CMP CMDS,X
709C  D0 19             BNE S2
                ;
709E  A5 FC             LDA SAVX        ; SAVE PREVIOUS CMD
70A0  85 F9             STA PREVC
70A2  86 FC             STX SAVX        ; SAVE CURRENT CMD INDEX
70A4  A9 71             LDA #MP1/256    ; JMP INDIRECT TO CMD CODE
70A6  85 ED             STA ACMD+1      ;   ALL CMD CODE BEGINS ON MP1
70A8  BD 0D 71          LDA ADRS,X
70AB  85 EC             STA ACMD
70AD  E0 03             CPX #3          ; IF :, R OR M (0, 1, OR 2)  SPACE 2
70AF  B0 03             BCS IJMP
70B1  20 74 73          JSR SPAC2
                ;
70B4  6C EC 00  IJMP    JMP (ACMD)
                ;
70B7  CA        S2      DEX
70B8  10 DF             BPL S1          ; LOOP FOR ALL CMDS
                ;
70BA  A9 3F     ERROPR  LDA #'?         ; OPERATOR ERR, TYPE '?', RESTART
70BC  20 C6 72          JSR WROC
70BF  90 C5             BCC START       ; JMP START (WROC RETURNS CY=0)
                ;
70C1  38        DCMP    SEC             ; TMP2-TMP0 DOUBLE SUBTRACT
70C2  A5 F0             LDA TMP2
70C4  E5 EE             SBC TMP0
70C6  85 F5             STA DIFF
70C8  A5 F1             LDA TMP2+1
70CA  E5 EF             SBC TMP0+1
70CC  A8                TAY             ;RETURN HIGH ORDER PART IN Y
70CD  05 F5             ORA DIFF        ; OR LO FOR EQU TEST
70CF  60                RTS
                ;
70D0  A5 EE     PUTP    LDA TMP0        ; MOVE TMP0 TO PCH,PCL
70D2  85 F6             STA PCL
70D4  A5 EF             LDA TMP0+1
70D6  85 F7             STA PCH
70D8  60                RTS
                ;
70D9  A9 00     ZTMP    LDA #0          ; CLEAR REGS
70DB  95 EE             STA TMP0,X
70DD  95 EF             STA TMP0+1,X
70DF  60                RTS
                ;
                ;  READ AND STORE BYTE.  NO STORE IF SPACE OR RCNT=0.
                ;
70E0  20 B3 73  BYTE    JSR RDOB        ; CHAR IN A, CY=0 IF SP
70E3  90 1C             BCC BY3         ; SPACE
                ;
70E5  A2 00             LDX #0          ; STORE BYTE
70E7  81 EE             STA (TMP0,X)
                ;
```

```
CARD # LOC      CODE         CARD
  291  7CE9  C1 FE              CMP (TMPO,X)       ; TEST FOR VALID WRITE (RAM)
  292  7CEB  F0 05              BEQ BY2
  293  7CED  68                 PLA                ; ERR, CLEAR JSR ADR IN STACK
  294  7CEE  68                 PLA
  295  7CEF  4C BA 7C           JMP ERROPR
  296                    ;
  297  7CF2  20 7C 72    BY2    JSR DADD           ; INCR CKSUM
  298  7CF5  20 97 73    BY3    JSR INCTMP         ; GO INCR TMPO ADR
  299  7CF8  C6 FE              DEC RCNT
  300  7CFA  60                 RTS
  301                    ;
  302  7CFB  A9 F8       SETR   LDA #FLGS          ; SET TO ACCESS REGS
  303  7CFD  85 FE              STA TMPO
  304  7CFF  A9 00              LDA #0
  305  7D01  85 FF              STA TMPO+1
  306  7D03  A9 05              LDA #5
  307  7D05  60                 RTS
  308                    ;
  309  7D06  3A          CMDS   .BYTE ':'
  310  7D07  52                 .BYTE 'R'
  311  7D08  4D                 .BYTE 'M'
  312  7D09  47                 .BYTE 'G'
  313  7D0A  48                 .BYTE 'H'
  314  7D0B  4C                 .BYTE 'L'
  315  7D0C  57                 .BYTE 'W'          ; W MUST BE LAST CMD IN CHAIN
  316  7D0D  3A          ADRS   .BYTE ALTER-MP1
  317  7D0E  14                 .BYTE DSPLYR-MP1
  318  7D0F  1C                 .BYTE DSPLYM-MP1
  319  7D10  5C                 .BYTE GO-MP1
  320  7D11  6F                 .BYTE HSP-MP1
  321  7D12  74                 .BYTE LH-MP1
  322  7D13  C2                 .BYTE WO-MP1
```

```
CARD # LOC      CODE         CARD
                            ;
                            ;
                            ;  NOTE -- ALL CMD CODE MUST BEGIN ON MP1
                            ;
                            ;  DISPLAY REG CMD - A,F,X,Y, AND SP
                            ;
       7114   20 A6 72   DSPLYR JSR WRPC          ; WRITE PC
       7117   20 FB 70          JSR SETR
       711A   D0 07             BNE MO            ; USE DSPLYM
                            ;
       711C   20 A4 73   DSPLYM JSR RDOA          ; READ MEM ADR INTO TMPC
       711F   90 16             BCC ERRS1         ; ERR IF NO ADDR
       7121   A9 08             LDA #8
       7123   85 FE      MO     STA TMPC
       7125   A0 00             LDY #0
       7127   20 77 73   M1     JSR SPACE         ; TYPE 8 BYTES OF MEM
       712A   B1 FE             LDA (TMPO),Y      ; (TMPO) PRESERVED FOR POSS ALTER
       712C   20 B1 72          JSR WROB
       712F   C8                INY               ; INCR INDEX
       7130   C6 FE             DEC TMPC
       7132   D0 F3             BNE M1
       7134   4C 86 70   BEQS1  JMP START
                            ;
       7137   4C BA 70   ERRS1  JMP ERROPR
                            ;
                            ;  ALTER LAST DISPLAYED ITEM (ADR IN TMPC)
                            ;
       713A   C6 E9      ALTER  DEC PREVC         ; R INDEX = 1
       713C   D0 0D             BNE A3
                            ;
       713E   20 A4 73          JSR RDOA          ; CY=0 IF SP
       7141   90 03             BCC A2            ; SPACE
       7143   20 DC 70          JSR PLTP          ; ALTER PC
       7146   20 FB 70   A2     JSR SETR          ; ALTER R'S
       7149   D0 05             BNE A4            ; JMP A4 (SETR RETURNS ACC = 5)
       714B   20 9A 72   A3     JSR WROA          ; ALTER M, TYPE ADR
       714E   A9 08             LDA #8            ; SET CNT=8
                            ;
       7150   85 FE      A4     STA RCNT
       7152   20 77 73   A5     JSR SPACE         ; PRESERVES Y
       7155   20 EC 70          JSR BYTE
       7158   D0 F8             BNE A5
       715A   F0 D8      A9     BEQ BEQS1
                            ;
       715C   A6 FC      GO     LDX SP
       715E   9A                TXS               ; ORIG OR NEW SP VALUE TO SP
       715F   A5 F7             LDA PCH
       7161   48                PHA
       7162   A5 F6             LDA PCL
       7164   48                PHA
       7165   A5 F8             LDA FLGS
       7167   48                PHA
```

MPL TIM PAGE 1

```
CARD # LOC      CODE        CARD
       7168  A5 F9               LDA ACC
       716A  A6 FA               LDX XR
       716C  A4 FB               LDY YR
       716E  40                  RTI
                         ;
       716F  E6 E8       HSP     INC HSROP          ; TOGGLE BIT 0
       7171  4C 86 7C            JMP START
                         ;
       7174  20 E9 72    LH      JSR RDOC           ; READ SECOND CMD CHAR
       7177  20 EA 72            JSR CRLF
       717A  A6 E8               LDX HSROP          ; ENABLE PTR OPTION IF SET
       717C  86 E7               STX HSPTR
       717E  20 E9 72    LH1     JSR RDOC
       7181  C9 3B               CMP #';            ; FIND NEXT RCD MARK (;)
       7183  D0 F9               BNE LH1
                         ;
       7185  A2 04               LDX #4
       7187  20 D9 7C            JSR ZTMP           ; CLEAR CKSUM REGS TMP4
       718A  20 B3 73            JSR RDOB
       718D  D0 06               BNE LH2
                         ;
       718F  A2 00               LDX #0             ; CLEAR HS RDR FLAG
       7191  86 E7               STX HSPTR
       7193  F0 9F               BEQ BEQS1          ; FINISHED
                         ;
       7195  85 FE       LH2     STA RCNT           ; RCNT
       7197  20 7C 72            JSR DADD           ; RCD LNGH TO CKSUM
       719A  20 B3 73            JSR RDOB           ; SA HO TO TMPO+1
       719D  85 EF               STA TMPO+1
       719F  20 7C 72            JSR DADD           ; ADD TO CKSUM
       71A2  20 B3 73            JSR RDOB           ; SA LO TO TMPO
       71A5  85 EE               STA TMPO
       71A7  20 7C 72            JSR DADD           ; ADD TO CKSUM
                         ;
       71AA  20 E0 7C    LH3     JSR BYTE           ; BYTE SUB/R DECRS RCNT ON EXIT
       71AD  D0 FB               BNE LH3
       71AF  20 A4 73            JSR RDOA           ; CKSUM FROM HEX RCD TO TMPO
       71B2  A5 F2               LDA TMP4           ; TMP4 TO TMP2 FOR DCMP
       71B4  85 F0               STA TMP2
       71B6  A5 F3               LDA TMP4+1
       71B8  85 F1               STA TMP2+1
       71BA  20 C1 7C            JSR DCMP
       71BD  F0 BF               BEQ LH1
       71BF  4C BA 70    ERRP1   JMP ERROPR
                         ;
       71C2  20 E9 72    WO      JSR RDOC           ; RD 2ND CMD CHAR
       71C5  85 FE               STA TMPC
       71C7  20 77 73            JSR SPACE
       71CA  20 A4 73            JSR RDOA
       71CD  20 87 73            JSR T2T2          ; SA TO TMP2
       71D0  20 77 73            JSR SPACE          ; SPACE BEFORE NEXT ADDRESS
       71D3  20 A4 73            JSR RDOA
```

```
LOC     CODE         CARD
71D6   20 87 73            JSR T2T2        ; SA TO TMP0, EA TO TMP2
71D9   20 E9 72            JSR RDOC        ; DELAY FOR FINAL CR
71DC   A5 FE               LDA TMPC
                      ;
71DE   C9 48               CMP #'H
71E0   D0 59               BNE WB
                      ;
71E2   A6 E4          WH0  LDX WRAP        ;IF ADDR HAS WRAPPED AROUND
71E4   D0 52               BNE BCCST       ;THEN TERMINATE WRITE OPERATION
                      ;
71E6   20 8A 72            JSR CRLF
71E9   A2 18               LDX #24
71EB   86 FE               STX RCNT        ; RCNT=24
71ED   A2 04               LDX #4          ; CLEAR CKSUM
71EF   20 D9 7C            JSR ZTMP
                      ;
71F2   A9 3B               LDA #';
71F4   20 C6 72            JSR WROC        ; WR RCD MARK
                      ;
71F7   20 C1 7C            JSR DCMP        ; EA-SA (TMP0+2-TMP0) DIFF IN LOC DIFF,+1
71FA   98                  TYA             ; MS BYTE OF DIFF
71FB   D0 0A               BNE WH1
71FD   A5 E5               LDA DIFF
71FF   C9 17               CMP #23
7201   B0 04               BCS WH1         ; DIFF GT 24
7203   85 FE               STA RCNT        ; INCR LAST RCNT
7205   E6 FE               INC RCNT
7207   A5 FE          WH1  LDA RCNT
7209   20 7C 72            JSR DADD        ; ADD TO CKSUM
720C   20 B1 72            JSR WROB        ; RCD CNT IN A
720F   A5 EF               LDA TMP0+1      ; SA HO
7211   20 7C 72            JSR DADD
7214   20 B1 72            JSR WROB
7217   A5 EE               LDA TMP0        ; SA LO
7219   20 7C 72            JSR DADD
721C   20 B1 72            JSR WROB
                      ;
721F   A0 00          WH2  LDY #0
7221   B1 EE               LDA (TMP0),Y
                      ;
7223   20 7C 72            JSR DADD        ; INC CKSUM, PRESERVES A
7226   20 B1 72            JSR WROB
7229   20 97 73            JSR INCTMP      ; INC SA
722C   C6 FE               DEC RCNT
722E   D0 EF               BNE WH2         ; LOOP FOR UP TO 24 BYTES
                      ;
7230   20 9E 72            JSR WROA4       ; WRITE CKSUM
                      ;
7233   20 C1 7C            JSR DCMP
7236   B0 AA               BCS WH0         ; LOOP WHILE EA GT OR = SA
7238   4C 86 7C       BCCST JMP START
                      ;
```

```
LCC      CODE           CARD
                        ;
723B     E6 FD          WB      INC SAVX          ; SAVX TO = NCMDS FOR ASCII SUB/R
723D     A5 E4          WB1     LDA WRAP          ;IF ADDR HAS WRAPPED ARCUND
723F     DC F7                  BNE BCCST         ;THEN TERMINATE WRITE OPERATION
                        ;
7241     A9 04                  LDA #4
7243     85 EC                  STA ACMD
7245     20 8A 72               JSR CRLF
7248     20 9A 72               JSR WROA          ; OUTPUT HEX ADR
                        ;
724B     20 77 73       WBNPF   JSR SPACE
724E     A2 09                  LDX #9
7250     86 FE                  STX TMPC          ; LOOP CNT =9
7252     A1 E5                  LDA (TMPC-9,X)
7254     85 FF                  STA TMPC2         ; BYTE TO TMPC2
7256     A9 42                  LDA #'B
7258     D0 08                  BNE WBF2          ; WRITE B
                        ;
725A     A9 50          WBF1    LDA #'P
725C     06 FF                  ASL TMPC2
725E     B0 02                  BCS WBF2
7260     A9 4E                  LDA #'N
                        ;
7262     20 C6 72       WBF2    JSR WRCC          ; WRITE N OR P
7265     C6 FE                  DEC TMPC
7267     D0 F1                  BNE WBF1          ; LOOP
7269     A9 46                  LDA #'F
726B     20 C6 72               JSR WROC          ; WRITE F
                        ;
726E     20 97 73               JSR INCTMP
                        ;
7271     C6 EC                  DEC ACMD          ; TEST FOR MULTIPLE OF FOUR
7273     D0 D6                  BNE WBNPF
                        ;
7275     20 C1 7C               JSR DCMP
7278     B0 C3                  BCS WB1           ; LOOP WHILE EA GT OR = SA
727A     90 BC                  BCC BCCST
                        ;
727C     48             DADD    PHA               ; SAVE A
727D     18                     CLC
727E     65 F2                  ADC TMP4
7280     85 F2                  STA TMP4
7282     A5 F3                  LDA TMP4+1
7284     69 00                  ADC #0
7286     85 F3                  STA TMP4+1
7288     68                     PLA               ; RESTORE A
7289     60                     RTS
                        ;
728A     A2 0D          CRLF    LDX #$0D
728C     A9 0A                  LDA #$0A
728E     20 C0 72               JSR WRTWC
7291     A6 E3                  LDX CRDLY         ;BIT-TIME COUNT FOR DELAY
```

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```
LOC       CODE        CARD
7293    20 1D 73   CR1     JSR DLY2             ;DELAY OF ONE BIT-TIME
7296    CA                 DEX
7297    D0 FA              BNE CR1
7299    60                 RTS
                   ;
                   ;  WRITE ADR FROM TMP0 STORES
                   ;
729A    A2 01      WROA    LDX #1
729C    D0 0A              BNE WROA1
729E    A2 05      WROA4   LDX #5
72A0    D0 06              BNE WROA1
72A2    A2 07      WROA6   LDX #7
72A4    D0 02              BNE WROA1
72A6    A2 09      WRPC    LDX #9
72A8    B5 ED      WROA1   LDA TMP0-1,X
72AA    48                 PHA
72AB    B5 EE              LDA TMP0,X
72AD    20 B1 72           JSR WROB
72B0    68                 PLA
                   ;
                   ;  WRITE BYTE - A = BYTE
                   ;  UNPACK BYTE DATA INTO TWO ASCII CHARS. A=BYTE; X,A=CHARS
                   ;
72B1    48         WROB    PHA
72B2    4A                 LSR A
72B3    4A                 LSR A
72B4    4A                 LSR A
72B5    4A                 LSR A
72B6    20 58 73           JSR ASCII            ; CONVERT TO ASCII
72B9    AA                 TAX
72BA    68                 PLA
72BB    29 0F              AND #$0F
72BC    20 58 73           JSR ASCII
                   ;
                   ;  WRITE 2 CHARS - X,A = CHARS
                   ;
72C0    48         WRTWO   PHA
72C1    8A                 TXA
72C2    20 C6 72           JSR WRT
72C5    68                 PLA
                   ;
                   ;  WRITE SERIAL OUTPUT
                   ;  A = CHAR TO BE OUTPUT
                   ;
72C6    20 1D 73   WRT     JSR DLY2
72C9    A2 09              LDX #9
                   WROC    =WRT
72CB    49 FF              EOR #$FF             ; COMPLEMENT A
72CD    38                 SEC
                   ;
72CE    20 DA 72   WRT1    JSR OUT
72D1    20 1D 73           JSR DLY2
```

```
LOC     CODE        CARD
72D4    4A                   LSR A
72D5    CA                   DEX
72D6    D0 F6                BNE WRT1
72D8    F0 3F                BEQ RDT5
                                              ; *USE BNE?
                    ;
72DA    48          OUT      PHA              ; SAVE A
72DB    AD 02 6E             LDA MPB          ; OUTPUT BIT FROM CY
72DE    29 FD                AND #%11111101
72E0    90 02                BCC OUT1
72E2    09 02                ORA #%00000010
72E4    8D 02 6E    OUT1     STA MPB
72E7    68                   PLA              ; RESTORE A
72E8    60                   RTS
                    ;
                    ;  OUTPUT  RETURNS CHAR IN A
                    ;
72E9    A5 E7       RDT      LDA HSPTR        ; TEST HS PTR OPTION
72EB    4A                   LSR A
72EC    B0 4F                BCS RDHSR
                    RDOC     =RDT
72EE    A2 08                LDX #8
                    ;
72F0    AD 02 6E    RDT1     LDA MPB
72F3    4A                   LSR A            ; WAIT FOR START BIT
72F4    90 FA                BCC RDT1
                    ;
72F6    20 20 73             JSR DLY1
72F9    20 DA 72             JSR OUT          ; ECHO START BIT
                    ;
72FC    20 1D 73    RDT2     JSR DLY2
72FF    AD 02 6E             LDA MPB          ; CY = NEXT BIT
7302    4A                   LSR A
7303    20 DA 72             JSR OUT          ; ECHO
                    ;
7306    08                   PHP              ; SAVE BIT
7307    98                   TYA              ; Y CONTAINS CHAR BEING FORMED
7308    4A                   LSR A
7309    28                   PLP              ; RECALL BIT
730A    90 02                BCC RDT4
730C    09 80                ORA #$80         ; ADD IN NEXT BIT
730E    A8          RDT4     TAY
730F    CA                   DEX
7310    D0 EA                BNE RDT2         ; LOOP FOR 8 BITS
7312    49 FF                EOR #$FF         ; COMPLEMENT DATA
7314    29 7F                AND #$7F         ; CLEAR PARITY
                    ;
7316    20 1D 73             JSR DLY2
7319    18          RDT5     CLC
731A    20 DA 72             JSR OUT          ;AND DELAY 2 HALF-BIT-TIMES
                    ;
731D    20 20 73    DLY2     JSR DLY1
```

```
CARD # LOC      CODE          CARD
       7320  48            DLY1    PHA               ; SAVE FLAGS AND A
       7321  08                    PHP
       7322  8A                    TXA               ; SAVE X
       7323  48                    PHA
       7324  A6 EA                 LDX MAJCRT
       7326  A5 EB                 LDA MINORT
                           ;
       7328  8D C4 6E      DL2     STA MCLK1T
                           ;
       732B  AD C5 6E      DL3     LDA MCLKIF
       732E  10 FB                 BPL DL3
       7330  CA                    DEX
       7331  08                    PHP
       7332  AD C4 6E              LDA MCLKRD        ; RESET TIMER INT FLAG
       7335  28                    PLP
       7336  10 F3                 BPL DL3
                           ;
       7338  68                    PLA               ; RESTORE REGS
       7339  AA                    TAX
       733A  28                    PLP
       733B  68                    PLA
       733C  60            DLX     RTS
                           ;
       733D  AD 02 6E      RDHSR   LDA MPB           ; LOOP ON DATA AVAIL
       7340  29 08                 AND #DAVAIL
       7342  F0 F9                 BEQ RDHSR
                           ;
       7344  AE 00 6E              LDX MPA           ; READ DATA
       7347  AD 02 6E              LDA MPB           ; SEND GOT-DATA PULSE
       734A  09 04                 ORA #GOTDAT
       734C  8D 02 6E              STA MPB
       734F  29 FB                 AND #%11111011
       7351  8D 02 6E              STA MPB
       7354  8A                    TXA
       7355  29 7F                 AND #$7F
       7357  60                    RTS
                           ;
       7358  18            ASCII   CLC
       7359  69 06                 ADC #6
       735B  69 F0                 ADC #$F0
       735D  90 02                 BCC ASC1
       735F  69 06                 ADC #$06
                           ;
       7361  69 3A         ASC1    ADC #$3A
       7363  48                    PHA               ; TEST FOR LETTER B IN ADR DURING WBNPF
       7364  C9 42                 CMP #'B
       7366  D0 0A                 BNE ASCX
       7368  A5 FD                 LDA SAVX
       736A  C9 07                 CMP #NCMDS
       736C  D0 04                 BNE ASCX          ; NOT WB CMD
       736E  68                    PLA
       736F  A9 20                 LDA #'            ; FOR WB, BLANK B'S IN ADR
```

```
LOC    CODE          CARD
7371   48                   PHA
7372   68            ASCX   PLA
7373   60                   RTS
                     ;
7374   20 77 73      SPAC2  JSR SPACE
7377   48            SPACE  PHA                  ; SAVE A,X,Y
7378   8A                   TXA
7379   48                   PHA
737A   98                   TYA
737B   48                   PHA
737C   A9 20                LDA #'
737E   20 C6 72             JSR WRT              ; TYPE SP
7381   68                   PLA                  ; RESTORE A,X,Y
7382   A8                   TAY
7383   68                   PLA
7384   AA                   TAX
7385   68                   PLA
7386   60                   RTS
                     ;
7387   A2 02         T2T2   LDX #2
7389   B5 ED         T2T21  LDA TMPC-1,X
738B   48                   PHA
738C   B5 EF                LDA TMP2-1,X
738E   95 ED                STA TMPC-1,X
7390   68                   PLA
7391   95 EF                STA TMP2-1,X
7393   CA                   DEX
7394   D0 F3                BNE T2T21
7396   60                   RTS
                     ;
                     ;INCREMENT (TMPC,TMPO+1) BY 1
7397   E6 EE         INCTMP INC TMPO             ;LOW BYTE
7399   F0 01                BEQ INCT1
739B   60                   RTS
                     ;
739C   E6 EF         INCT1  INC TMPC+1           ;HIGH BYTE
739E   F0 01                BEQ SETWRP
73A0   60                   RTS
                     ;
73A1   E6 E4         SETWRP INC WRAP             ;POINTER HAS WRAPPED AROUND - SET FLAG
73A3   60                   RTS
                     ;
                     ; READ HEX ADR, RETURN HO IN TMPO, LO IN TMPO+1 AND CY=1
                     ;      IF SP CY=0
                     ;
73A4   20 B3 73      RDOA   JSR RDOB             ; READ 2 CHAR BYTE
73A7   90 02                BCC RDOA2            ; SPACE
                     ;
73A9   85 EF                STA TMPO+1
73AB   20 B3 73      RDOA2  JSR RDOB
73AE   90 02                BCC RDEXIT           ; SP
73B0   85 EE                STA TMPO
```

```
CARD # LOC     CODE        CARD
       73B2   60          RDEXIT RTS
                          ;
                          ;  READ HEX BYTE AND RETURN IN A, AND CY=1
                          ;     IF SP CY=0
                          ;     Y REG IS PRESERVED
                          ;
       73B3   98          RDOB   TYA                ; SAVE Y
       73B4   48                 PHA
       73B5   A9 00              LDA #0             ; SET DATA = 0
       73B7   85 EC              STA ACMD
       73B9   20 E9 72           JSR RDOC
       73BC   C9 0D              CMP #$0D           ; CR?
       73BE   D0 06              BNE RDOB1
       73C0   68                 PLA                ;YES - GO TO START
       73C1   68                 PLA                ;CLEANING STACK UP FIRST
       73C2   68                 PLA
       73C3   4C 86 70           JMP START
                          ;
       73C6   C9 20       RDOB1  CMP #'             ; SPACE
       73C8   D0 0A              BNE RDOB2
       73CA   20 E9 72           JSR RDOC           ; READ NEXT CHAR
       73CD   C9 20              CMP #'
       73CF   D0 0F              BNE RDOB3
       73D1   18                 CLC                ; CY=0
       73D2   90 12              BCC RDOB4
                          ;
       73D4   20 EB 73    RDOB2  JSR HEXIT          ; TO HEX
       73D7   0A                 ASL A
       73D8   0A                 ASL A
       73D9   0A                 ASL A
       73DA   0A                 ASL A
       73DB   85 EC              STA ACMD
       73DD   20 E9 72           JSR RDOC           ; 2ND CHAR ASSUMED HEX
       73E0   20 EB 73    RDOB3  JSR HEXIT
       73E3   05 EC              ORA ACMD
       73E5   38                 SEC                ; CY=1
       73E6   AA          RDOB4  TAX
       73E7   68                 PLA                ; RESTORE Y
       73E8   A8                 TAY
       73E9   8A                 TXA                ;SET Z & N FLAGS FOR RETURN
       73EA   60                 RTS
                          ;
       73EB   C9 3A       HEXIT  CMP #$3A
       73ED   08                 PHP                ; SAVE FLAGS
       73EE   29 0F              AND #$0F
       73F0   28                 PLP
       73F1   90 02              BCC HEX09          ; 0-9
       73F3   69 08              ADC #8             ; ALPHA ADD 8+CY=9
       73F5   60          HEX09  RTS
                          ;
       73F6                      *=MP3+$F8
                          ;
```

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CARD # LOC      CODE        CARD
  792  73F8  CC 7C      INTVEC .WORD NMINT        ; DEFAULT USER INTRQ TO NMINT
  793  73FA  C0 70             .WORD NMINT
  794  73FC  C6 7C             .WORD RESET
  795  73FE  52 7C             .WORD INTRQ
  796                   ;

END OF MOS/TECHNOLOGY 6501 ASSEMBLY VERSION 3
NUMBER OF ERRORS =    0,  NUMBER OF WARNINGS =    0
```

SYMBOL TABLE

SYMBOL	VALUE	LINE DEFINED	CROSS-REFERENCES							
ACC	00F9	120	140	194	227	376				
ACMD	00EC	112	246	248	253	486	511	749	[illegible]	774
ADRS	71CC	316	247							
ALTER	713A	351	316							
ASCII	735B	673	560	564						
ASCX	7372	689	682	685						
ASC1	7361	679	676							
A2	7146	357	355							
A3	714B	359	352							
A4	7150	362	358							
A5	7152	363	365							
A9	715A	366								
BCCST	7238	478	436	483	516					
BEQS1	7134	345	366	399						
BX	7081	227	198							
BYTE	70EC	285	364	410						
BY2	70F2	297	292							
BY3	70F5	298	286							
B3	7058	201	142							
B5	7073	219								
CMDS	71C6	309	239							
CRDLY	00E3	104	163	531						
CRLF	728A	528	219	233	385	438	487			
CR1	7293	532	534							
DADD	727C	518	297	402	405	408	456	459	462	468
DAVAIL	0008	85	660							
DCMP	70C1	262	417	447	476	514				
DIFF	00E5	106	265	269	450					
DLX	733C	657								
DLY1	732C	636	611	635						
DLY2	731D	635	532	576	583	614	631			
DL2	7328	643								
DL3	732B	645	646	651						
DSPLYM	711C	334	318							
DSPLYR	7114	330	317							
ERROPR	70BA	258	295	347	419					
ERRP1	71BF	419								
ERRS1	7137	347	335							
FLGS	00F8	119	209	302	374					
GC	715C	368	319							
GOTDAT	00C4	86	665							
HEXIT	73EB	782	766	773						
HEXC9	73F5	788	786							
HSP	716F	381	320							
HSPTR	00E7	107	155	231	387	398	601			
HSROP	00E8	108	156	381	386					
IJMP	70B4	253	250							
INCTMP	7397	719	298	470	509					
INCT1	739C	723	720							
INTRQ	7052	194	795							
INTVEC	73F8	792	149							

SYMBOL	VALUE	LINE DEFINED	CROSS-REFERENCES									
IOBASE	6ECC	87	88	89	90	91	92	93	94			
LCNT	C0FF	128										
LH	7174	384	321									
LH1	717E	388	390	418								
LH2	7195	401	395									
LH3	71AA	410	411									
MAJORT	C0EA	110	154	171	184	640						
MCLKIF	6E05	94	165	645								
MCLKRD	6EC4	93	181	649								
MCLKIT	6EC4	92	168	643								
MDA	6EC1	89										
MDB	6EC3	91	146									
MDBK	0016	84	144									
MINORT	C0EB	111	189	641								
MPA	6EC0	88	663									
MPB	6EC2	90	164	175	591	595	607	615	659	664	666	668
MPC	70CC	97	138									
MP1	71CC	98	245	316	317	318	319	320	321	322		
MP2	72CC	99										
MP3	73CC	100	790									
M0	7123	337	332									
M1	7127	339	344									
NCMDS	C007	96	238	684								
NMINT	70CC	140	792	793								
OUT	72DA	590	582	612	617	633						
OUT1	72E4	595	593									
PCH	C0F7	118	215	275	370							
PCL	C0F6	117	212	273	372							
PREVC	00E9	109	243	351								
PUTP	70DC	272	356									
RAM64	FFCC	132	133									
RCNT	C0FE	127	299	362	401	440	453	454	455	471		
RDEXIT	73B2	740	738									
RDHSR	733D	659	603	661								
RDOA	73A4	733	334	354	412	424	427					
RDOA2	73AB	737	734									
RDOB	73B3	746	285	394	403	406	733	737				
RDOB1	73C6	758	752									
RDOB2	73D4	766	759									
RDOB3	73EC	773	762									
RDOB4	73E6	776	764									
RDOC	72E9	604	236	384	388	421	429	750	760	772		
RDT	72E9	601	604									
RDT1	72FC	607	609									
RDT2	72FC	614	627									
RDT4	73CE	625	623									
RDT5	7319	632	587									
RESET	7006	144	794									
R0	7022	164	166									
R1	70CD	149	152									
R2	7028	168	172									
R3	702B	169	177	179								
R4	7034	174	170									
R5	7044	183	188									

SYMBOL	VALUE	LINE DEFINED	CROSS-REFERENCES									
R6	704B	187	185									
SAVX	00FC	124	242	244	481	683						
SETR	70FB	302	331	357								
SETWRP	73A1	727	724									
SP	00FC	123	217	368								
SPACE	7377	693	339	363	423	426	490	692				
SPAC2	7374	692	251									
START	7086	230	260	345	382	478	756					
S0	7097	238	225									
S1	7099	239	256									
S2	70B7	255	240									
TMPC	00FE	125	127	201	220	337	343	422	430	492	504	
TMPC2	00FF	126	128	494	499							
TMP0	00EE	113	264	267	272	274	279	280	289	291	303	305
			340	404	407	458	461	466	493	546	548	708
			711	719	723	736	739					
TMP2	00F0	114	263	266	414	416	710	713				
TMP4	00F2	115	413	415	520	521	522	524				
TMP6	00F4	116										
T2T2	7387	707	425	428								
T2T21	7389	708	715									
UINT	FFF8	95	150	228								
WB	723B	481	433									
WBF1	725A	498	505									
WBF2	7262	503	496	500								
WBNPF	724B	490	512									
WB1	7230	482	515									
WHC	71E2	435	477									
WH1	7207	455	449	452								
WH2	721F	465	472									
WC	71C2	421	322									
WRAP	00E4	105	232	435	482	727						
WROA	729A	539	359	488								
WRCA1	72A8	546	540	542	544							
WRCA4	729E	541	474									
WROA6	72A2	543										
WRCB	72B1	555	341	457	460	463	469	549				
WROC	72C6	578	235	259	445	503	507					
WRPC	72A6	545	330									
WRT	72C6	576	570	578	699							
WRTWO	72C0	568	223	530								
WRT1	72CE	582	586									
XR	00FA	121	206	377								
YR	00FB	122	207	378								
ZTMP	70C9	278	393	442								

INSTRUCTION	COUNT
ADC	9
AND	9
ASL	6
BCC	15
BCS	6
BEQ	11
BIT	0
BMI	0
BNE	33
BPL	5
BRK	1
BVC	0
BVS	0
CLC	4
CLD	1
CLI	1
CLV	0
CMP	11
CPX	1
CPY	0
DEC	6
DEX	8
DEY	1
EOR	4
INC	7
INX	0
INY	2
JMP	9
JSR	89
LDA	65
LDX	24
LDY	4
LSR	13
NOP	0
ORA	6
PHA	18
PHP	4
PLA	23
PLP	4
ROL	0
RTI	1
RTS	19
SBC	2
SEC	3
SED	0
SEI	0
STA	45
STX	11
STY	2
TAX	4
TAY	4
TSX	1
TXA	5
TXS	2
TYA	5