Interactive Control

Completing the Loop for Total Automation

by
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May 29, 1985
MAE 412
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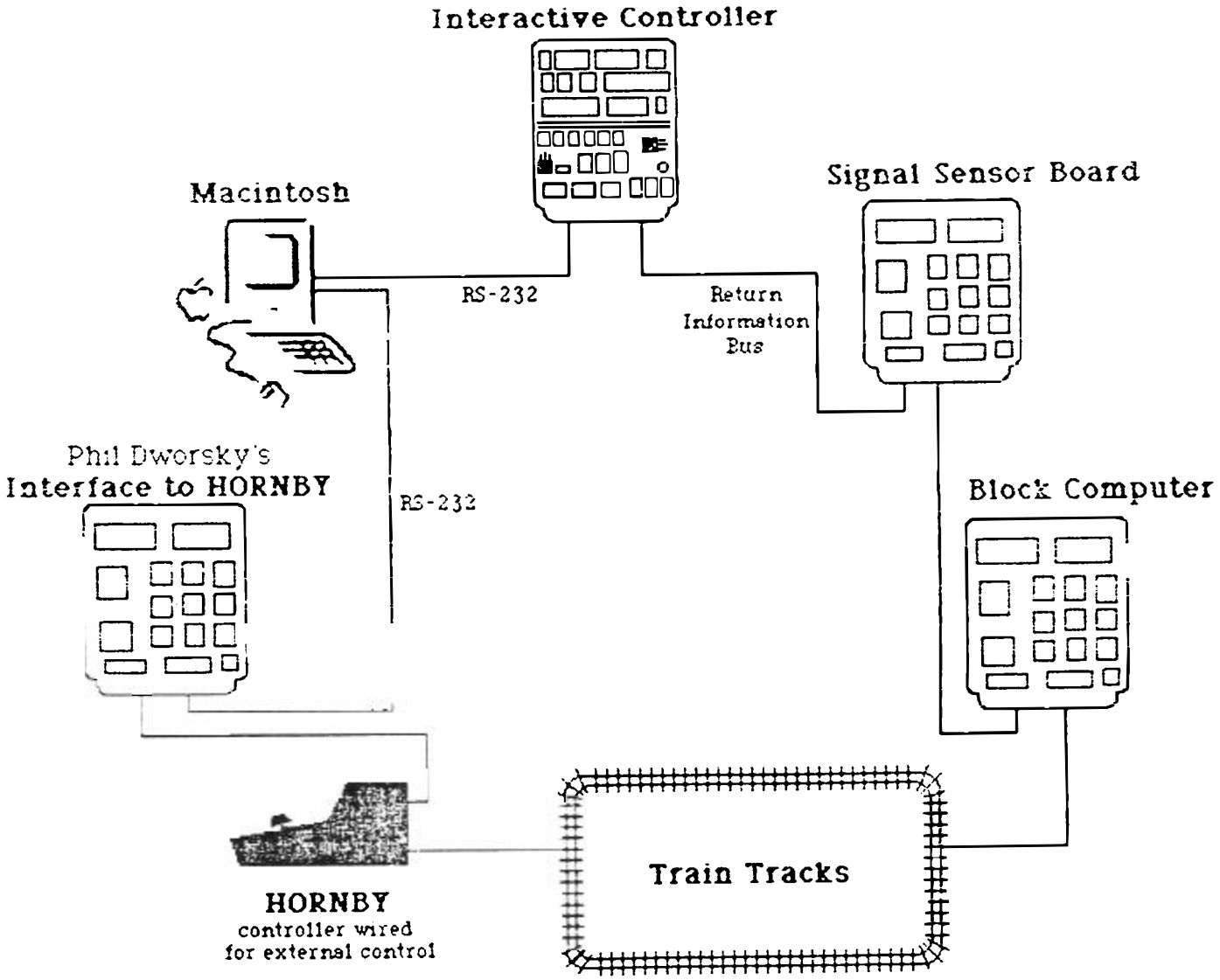


ABSTRACT

A software and hardware interface between the block computers on the main line and the HORNBY Zero-1 controller. The block computers are already able to receive information from the HORNBY controller via the interrupt service routine. So this project enables the total automation of the main line without the need for a person to monitor the system.

INTRODUCTION

The automation loop involves many intermediate steps. The block computers send their sixteen bits of return information to their signal sensor boards. These boards are all attached to a single bus called the **Return Information Bus.** During the data frame of the HORNBY power cycle, the signal sensor board sends the information to the 6502 based project I designed. My project then sends the information via an RS-232 300 baud interface to the MacIntosh computer. The MacIntosh then processes the information and determines the appropriate actions to be taken which results in a string of characters. The string is the sent over an RS-232 300 baud interface to Phil Dworsky's project which interprets the characters in the string and the simulates the keypushes on the HORNBY controller unit. The controller the sends information out to the tracks to control the locomotives and talk to the block computers. And finally, the block computers read information off of the tracks via Lecky's interrupt service routine.

HARDWARE

The board I developed uses a 6502 microcomputer to manage shift registers for the Return Information Bus and an ACIA to manage the RS-232 port.

Shift Registers and Logic

A comment about the hardware in general: because of the timing restrictions and noise problems, the exact chip numbers and types should be used if the project is to be copied. Do not substitute LS for S chips, etc. because the timing will not remain within specifications.

The address decoding logic is drawn in Figure #1 on the following page. All chips become enabled with an active low signal. The RAM and LEDs do not directly accept ϕ_2 as an input (as does the VIA, and the ACIA) so the output of the LS138 is OR'ed with NOT ϕ_2. When ϕ_2 goes from low to high (and NOT ϕ_2 goes from high to low which enables the chips), this becomes a reference for the write timing for these devices.

The data that the HORNBY controller sends during a data frame consists of 34 bits of information. Each bit is frequency shift keyed so each bit is a full square-wave cycle (see Special Note below). I use one of the JK flip flops (configured as a T flip flop) in the 7476 as a divide-by-2 counter since one bit of return information is sent for every two bits of track information. I use two 8 bit shift registers (7491A) and the other JK flip flop (configured as a D flip flop) to hold the

seventeenth bit. Figure #2 on the following page shows the track signal and the corresponding clock signal for shifting the registers. A high-to-low transition clocks the shift registers and flip flop. The XOR gate (LS86) that goes into the clock flip flop is used to account for different track polarities. PAØ is set low if the transition of the first bit in the data frame goes from high to low and set high for the other polarity. Therefore, the first transition of the track signal always creates a high-to-low transition into the clock the flip flop. At the end of the first bit of data, there will be another high to low transition so the flip flop will toggle to low thus triggering the shift registers.

The output of the clock flip flop is NAND'ed with PB7 which is high during a data frame and low otherwise. So the shift registers can only be triggered by the track while in a data frame. Finally, the output is NAND'ed with PA1 which is normally high and is pulsed low when the software is reading in the shift registers after the data frame.

Special Note: The drawing for the track signal in Figure #2 shows 35 low-to-high transitions and 34 high-to-low transitions. Since the clock flip flop is clocked on the first transition (low-to-high which is converted to high-to-low by the XOR gate), it should get 35 pulses but the output of the clock signal shows only 34 transitions. Professor Littman believes that it is possible that the last cycle bit of the data frame does not exist so that would account for the output.

Logic Diagrams

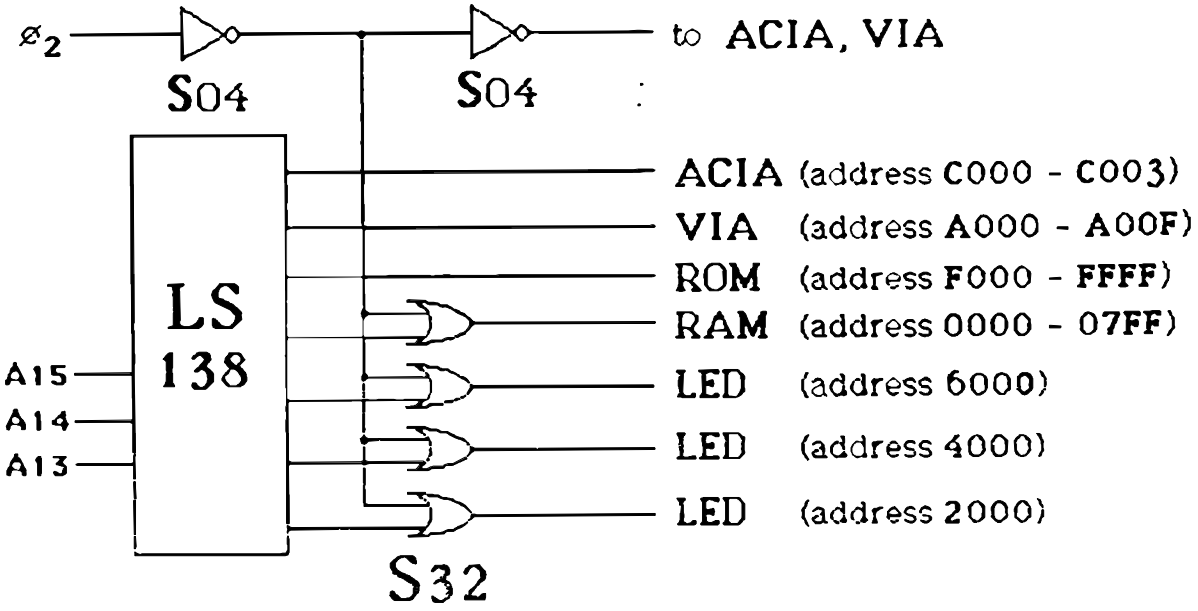


Figure #1

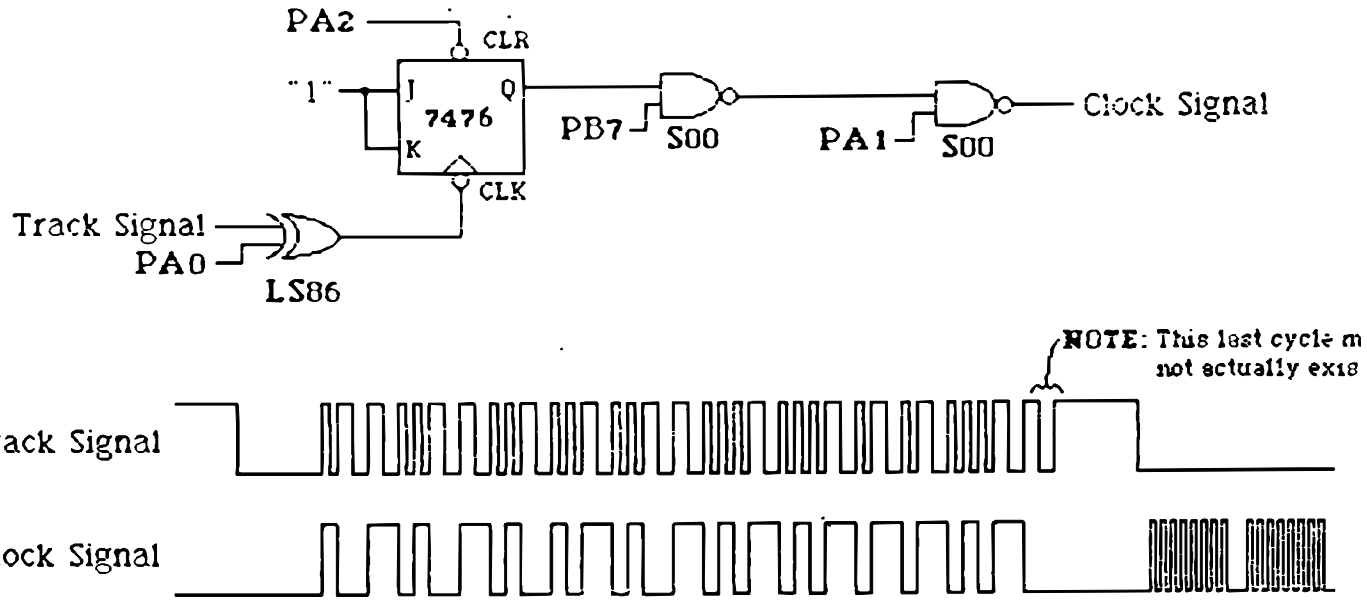


Figure #2

ACIA

This operation is much simpler. The logic signal from the 6522 goes into an MC1488 which makes it the correct voltage levels for RS-232 communication. The MC1488 needs a negative power supply so an ICL7660 is used which converts +5 volts into -5 volts. The MC1488 also needs a positive voltage greater than +5 volts so the unregulated +9 volts from the supply is used. For receiving RS-232, I copied the circuit that the AIM-65 uses. If you look on the Schematic Diagram, you can see that the input line goes between two diodes; one from ground to the line and the other from the line to +5 volts. This properly converts the usual ±12 volts.

SPECIAL

1) There are two regulators for the project. One drives all the logic components and the other drives only the LEDs. This regulator's output is denoted by +5L on the Schematic Diagram.

2) Because the LEDs draw so much current, a large 9 volt power supply that can supply at least one amp should be used.

3) The flip flops are very sensitive to spikes so pull up resistors and capacitors were used for all lines requiring a logic "1" (i.e. +5 volts).

4) When powering up the components of the system, there is a preferred order. First power the HORNBY controller, then all the block computers, then my project computer, and finally start the MacIntosh program running. This helps minimize garbage coming

up on the **Return Information Bus.**

5) The blue and white wires coming out of the 44 pin connector on my project are the **Return Information Bus.** The blue wire is GROUND and should be connected to pin 17 on the signal sensor board's 44 pin connector. The white wire should connect to pin 16 of the signal sensor board. NOTE: Most signal sensor boards are missing the **4N33** that drives the **Return Information Bus** so this may need to be installed. See the layout of the signal sensor board in the train lab for more details.

SOFTWARE

software for the interface is composed of two parts: a program in the EPROM of my project computer, and a BASIC program that runs on the MacIntosh.

Interactive Control Program in EPROM

listing with a line by line description of operation can be found at the end of this report. The general functioning of the program is as follows. During frame #1, the sixteen bits in the shift registers are read. Then two flags are checked to see if special processing needs to be done. The first one is a flag that says that the information just read in was the return information from a poll request of all computers. Therefore, set the lowest bit of the 16 bits to a "1" and send it. The MacIntosh checks that the lowest bit is set otherwise it assumes that the information just received was garbage. The next flag that is checked if the first wasn't true is one of the Lecky mailboxes **INTMPU**. This signal says that the **following** data frame will contain return information from a poll request. Therefore, set the poll request flag for next time, throw away the 16 bits just read in, and wait for frame 4. The reason for throwing away the information just read, is that it takes 53 milliseconds to send two bytes of data at 300 baud. Since each frame spans approximately 8.3 milliseconds (60 Hz), the 5 frames span 41.5 milliseconds. Therefore, if the information was sent, the

program would miss the data frame with the return information by the time it returned from the sending routine. If neither of the flags were set then both bytes are checked for being zero. If they are both zero then they are not displayed or sent. Finally, the program waits for frame 4 where it clears the flip flops and prepares for the following data frame.

Hornby Controller Program

The listing for this program can also be found at the end of the report. The program has three main parts: the first controls manual operation, the second controls automatic operation, and the third handles editing of command tables. When the program starts, it asks you to edit and/or load the command tables and then hit return. This allows you to set up the system before beginning operation. You can save or load command tables by selecting the FILE menu and the appropriate field. The list of files on the disk is displayed and you can select on by clicking it twice. (In the case of SAVE, if you want to save the table under a new name then hit cancel and a new prompt box will appear with a field to fill in the name from the keyboard.)

When you hit RETURN, you enter the MANUAL mode of operation where the user directly controls the trains instead of the block computers. To get to the AUTOMATIC mode of operation, select the MODE menu and the Automatic field and then click one of the "buttons" on the screen. To get from AUTOMATIC mode to MANUAL mode simply select the Manual field of the MODE menu.

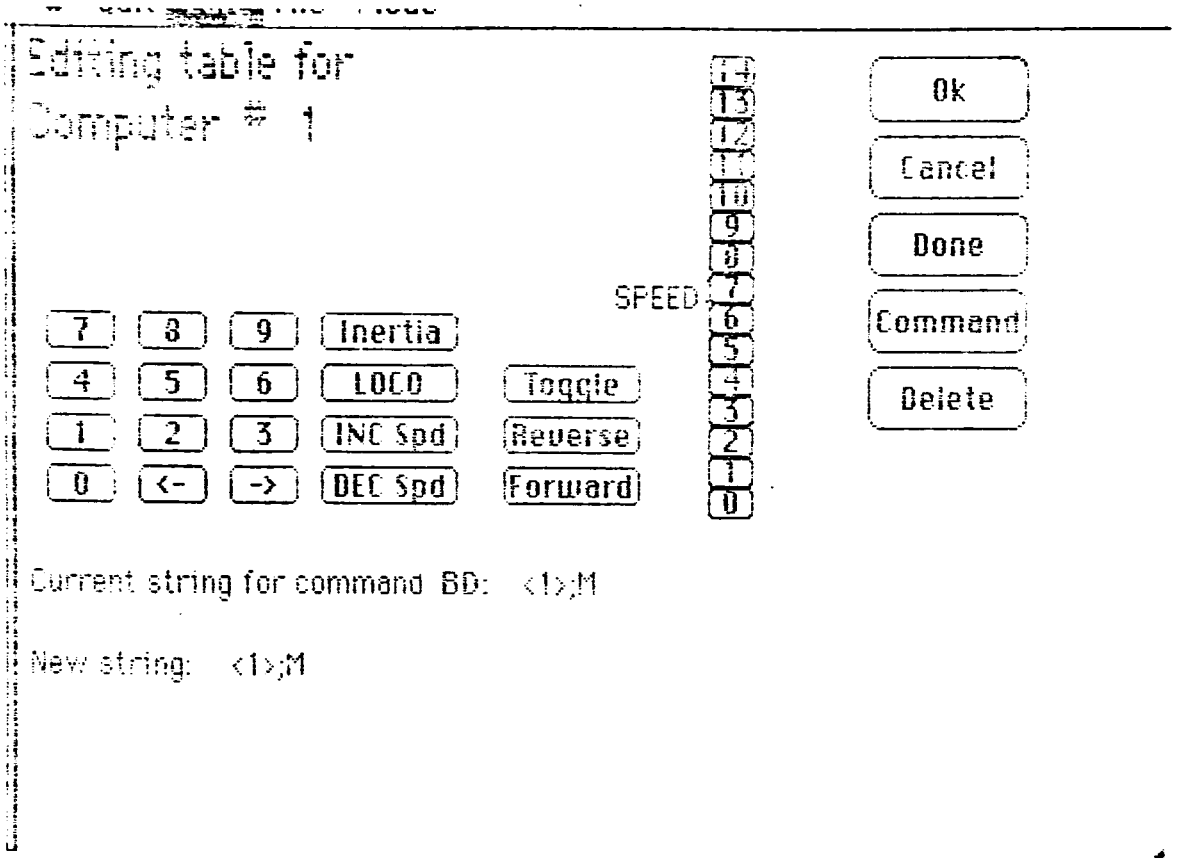
Manual Mode

The screen dump on the following page shows the basic layout for the manual mode screen and the editing screen (each has a few differences). Each little box on the screen is a BASIC BUTTON. Clicking one of these "buttons" with the mouse is equivalent to pressing the buttons on the HORNBY controller. There are some buttons that are different or missing from the HORNBY layout. There is no PANIC, CLEAR, or SLAVE keys. But I have added INCrement Speed, DECrement Speed, and TOGGLE direction for the convenience of the user. The program stores the direction and speeds of each train in arrays, so hitting TOGGLE will cause a lookup of the direction of the ActiveLoco and flip that bit in the array. It then determines whether to send a FORWARD or REVERSE character. Also, the program keeps track of the ActiveLoco by remembering the number of the last LOCO entered. NOTE: Even though the user can control more than one loco with the "slide", the program only remembers the last one.

Automatic Mode

The basic idea behind automatic operation is this: each computer has an ID number (1-9). The return information consists of two bytes. Each byte is an index into an array of 256 command strings. Each command string contains a sequence of keypushes of the HORNBY keypad to be executed.

In Automatic mode, the MacIntosh can handle up to 9 block computers. It first sends out a poll request to all computers.


Editing table for
Computer # 1
SPEED
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
7
8
9
Inertia
4
5
6
LOCO
Toggle
1
2
3
INC Spd
Reverse
0
<-
->
DEC Spd
Forward
Ok
Cancel
Done
Command
Delete
Current string for command BD: <1>;M
New string: <1>;M

Then it waits for two bytes of return information. It then checks to make sure that the lowest bit was set by my computer. Then it determines which computers need servicing. It then polls each computer in turn for its return information. It then waits for two bytes of information from the Current Computer being polled. Then it uses the high byte as an index into the Current Computer's command table. The string returned is then executed (if not empty) by deciphering the the string, setting appropriate values for ActiveLoco and the arrays Direction, Speed, CompCurrLoco. ActiveLoco, Direction, and Speed were described above. CompCurrLoco is the number of the loco that a particular computer is controlling. The reason this is needed is demonstrated by the following example:

> There are two computers on the main line, #3 and #5. Both have return information. The Mac polls #3 first. This computer wants to set LOCO 7 to Speed 2. Then the Mac polls #5. It wants to set LOCO 1 in REVERSE at Speed 14. The Mac then polls both computers again. Computer #3 has return information. The Mac polls #3 and receives the command to INCrement Speed. The Mac checks to see whether the ActiveLoco is the same as the #3 Computer's Current Loco (in the array CompCurrLoco) Since the ActiveLoco is number 1 (set by computer #5), the Mac first sends out a string setting the ActiveLoco to 7 and then determines that the new Speed should be 3 and sends that string out.

This situation allows the computers to act independently of other computers on the line since they don't have to know about current locos and such. However, a problem could arise if two computers are controlling the same LOCO. One computer could set it to REVERSE and the other to FORWARD so neither project would

function properly. But you could modify this program to save speed and direction in more arrays for each computer if this becomes a real necessity.

EDITOR

The reasons behind using tables of command strings instead each user writing his own subroutine in BASIC are numerous. First of all, since everyone uses a table with 255 command strings (ØØ is not an allowed command), this helps standardize system. Also, user written subroutines might affect the operation of other subroutines. It also facilitates the uses of multiple user systems. Also, the user does not have to know anything about BASIC programming or what characters to send, etc. They only need to know how to use a HORNBY keypad.

When you select the EDIT menu, the screen depicted earlier is displayed. The program then prompts you for the computer number of the table you want to edit. Select a new command byte by hitting the COMMAND button. You are prompted for a 2 digit number. The old value of the string is displayed (which will probably look incomprehensible since it is a string of characters which each key translates. See table of keys and characters at end of report.) Enter a new sequence of keys by clicking the "keys" of the HORNBY layout. The speed slide is replaced by 15 distinct speed settings. If you make a mistake, use the DELETE button to erase the last character of the New string. When finished entering the string, hit OK to save this new string or CANCEL to forget it. NOTE: While entering a new string, the DONE and COMMAND buttons are disabled so that you do not accidentally forget to save a newly entered string. Clicking either OK or CANCEL re-enables them. Hit DONE when you are ready to return to the normal operation of the program.

SPECIAL

1) A problem can occur if the program is in Automatic mode and the track is shorted. The MacIntosh will have sent a poll request and then wait for two bytes of information. Since the block computers never received the request the Mac will wait forever. But there are two ways to fix this. On the HORNBY controller, hit CLEAR and then enter a poll request by hitting "0 1 ->". If this doesn't work then you might reset my project then repeat the above procedure. A second method can be done by switching to Manual mode on the Mac and then back to Automatic mode (after CLEARing the HORNBY). This will send a new poll request. Again, you might have to reset my project.

2) Also, the Mac might hang if th return information sent by a block computer is all zeros. My project never sends return information to the Mac if both bytes are zero. My only suggestion to prevent this is to enfore the rule that at least one byte of return information has to be non-zero. In fact, I suggest that the normal format for return information should be to set the high byte to zero and the loww byte to the desired command. If, however, you need to execute a very long command string at one time then you could send two commands. The high byte would contain the code for the first half of the command string and the low byte would be the code for the continuation of the command string. See note 4) below.

3) As a convention for naming command tables stored on disk, I use the descriptive name of the project followed by the

computer number it is to be loaded into. For example, the two that are on the "Mike Arena" disk are "Busloader4" and "Turntable1". So the project that controls the turntable would be loaded as the first table in the array of nine tables.

4) Also as a convention, I decided that each command string stored in the command tables could be 20 characters long. Each charcter is equivalent to one keypush. This makes the size of the table when saved to disk 5K. The two tables saved on disk are in this format so if you need to expand the size of a string then I suggest linking two bytes together rather than changing the size of the strings. The Mac executes the high byte's string first and then the low byte's string so you could consider this one string of length 40.

5) Since the array of tables in the Mac prgram is 9x256x20, this takes up 45K of RAM, so the program can only be run on a Mac with 512K.

6) While in manual mode, ignore the buttons OK, CANCEL, DONE, COMMAND, and DELETE. They only have meaning in the editor.

7) When the Mac executes a command string, it deciphers the string and prints on the screen what operations are being performed. But then I never bothered to clean up the screen for the next command so this could be fixed in the program.

CONCLUSION

The project works very reliably and performs all the functions that I set out to do at the beginning of the semester. The automatic system has been tested with only one block computer at a time, but I assume that it will work the same with multiple computers.

Since the main software runs on a MacIntosh, it will be very easy to modify the program to suit the needs of future projects. New "keys" could be added to the HORNBY layout to incorporate more functions. I hope that this project will prove to be extremely useful to future students in the course.

Michael J. Arena

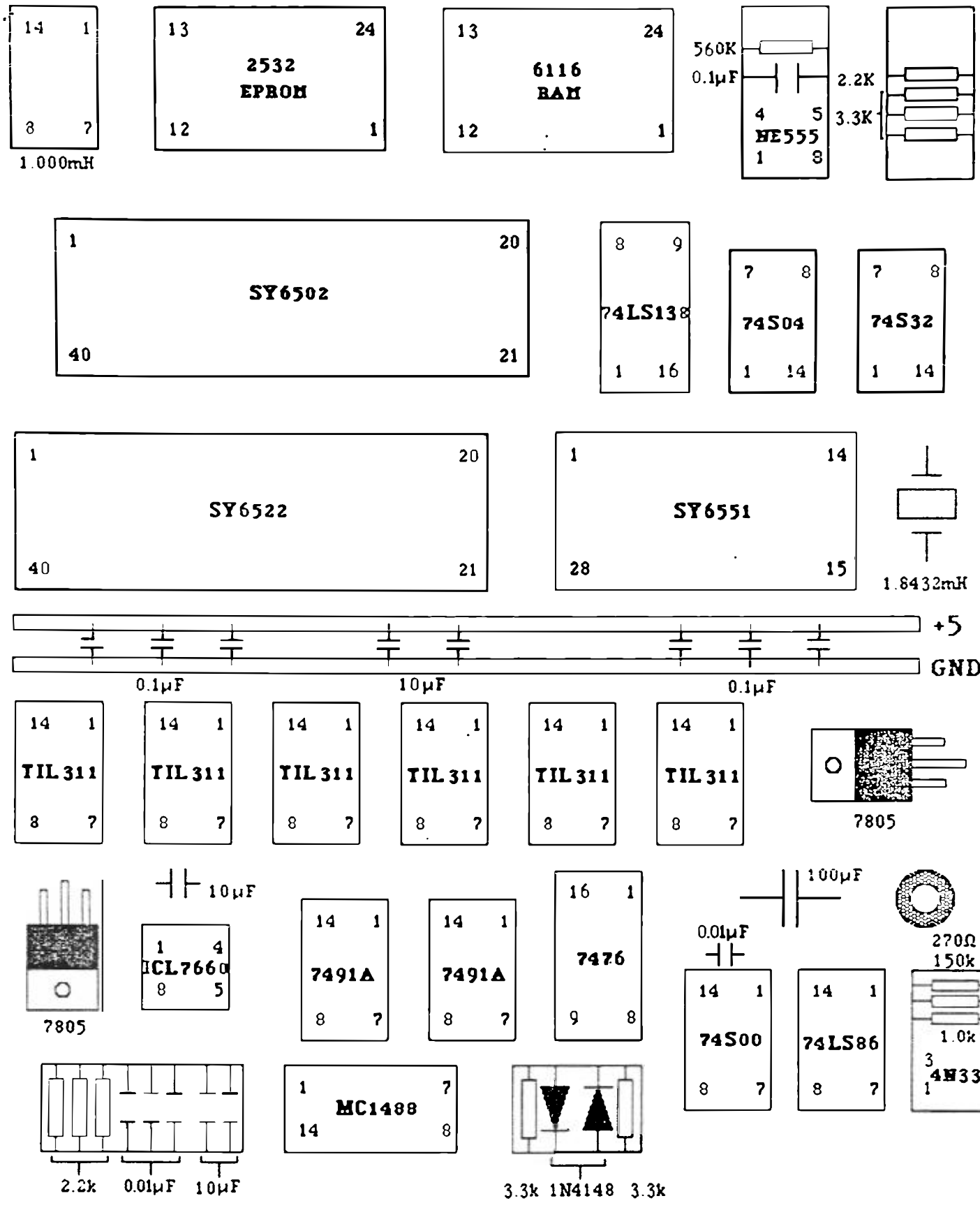
List of HORNBY keys and their equivalent characters in the program

(This is from Phil Dworsky's report except for my extra keys)

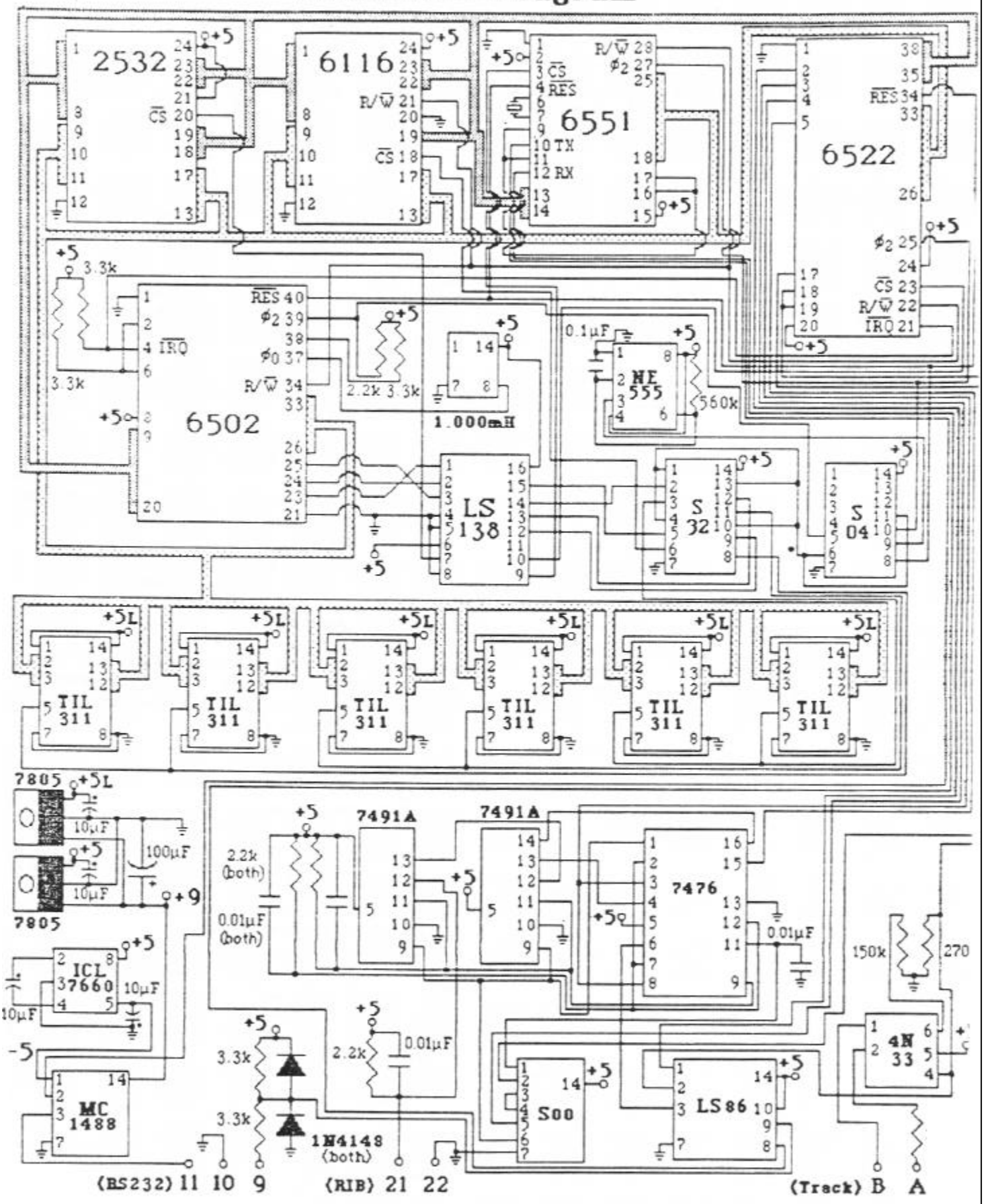
Speed	Character
0	A
1	C
2	B
3	F
4	G
5	E
6	D
7	L
8	M
9	O
10	N
11	J
12	K
13	I
14	H

HORNBY Key	Character
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
INERTIA	:
REVERSE	;
FORWARD	?
LOCO	<
<-	=
->	>
INC Spd	+
DEC Spd	-
TOGGLE	~

Back View


14 1
8 7
1.000mH
13 24
2532
EPROM
12 1
13 24
6116
RAM
12 1
560K
0.1µF
4 5
HE555
1 8
2.2K
3.3K
1 20
SY6502
40 21
8 9
74LS138
1 16
7 8
74S04
1 14
7 8
74S32
1 14
1 20
SY6522
40 21
1 14
SY6551
28 15
1.8432mH
+5
GND
0.1µF
10µF
0.1µF
14 1
TIL311
8 7
7805
10µF
1 4
ICL7660
8 5
7805
14 1
7491A
8 7
14 1
7491A
8 7
16 1
7476
9 8
100µF
0.01µF
270Ω
150k
14 1
74S00
8 7
14 1
74LS86
8 7
1.0k
3 4
4N33
1 6
1 7
MC1488
14 8
2.2k
0.01µF
10µF
3.3k
1N4148
3.3k

Schematic Diagram



Interactive Control Program

in EPROM

```
Start       SEI             ; The next 4 instructions are the usual
            CLD             ; initialization instructions
            LDX  #FF
            TXS
            LDA  #01        ; Set computer number to 1
            STA  03FA       ; Mailbox for computer number
            STA  0200       ; Location 0200 holds the bit for PA0
                            ; which is either set or cleared depen-
                            ; ding on the polarity of the track.
                            ; This is explained in the writeup
            JSR  FB00       ; Jump to initialization routine
            LDX  #F7        ; Mask for direction of Port A on VIA
            STX  A003       ; Sets all but PA3 to outputs
            JSR  InitACIA   ; Initialize the RS232 port
            LDA  #00        ; Location 0205 is a flag to signal that
            STA  0205       ; the next data frame will contain the
                            ; return data from a poll request
            LDA  03F5       ; Load the PLRTY mailbox
            BEQ  MainLoop   ; If zero then start main loop
            LDA  #00        ; Else zero out location 0200
            STA  0200
MainLoop    LDA  0200       ; Load bit for PA0
            ORA  #02        ; Set PA1 high and PA2 low
            STA  A001       ; Store in Port A's data register
            ORA  #06        ; Bring PA2 back high.  Pulsing PA2
                            ; clears the JK flipflops before reading
                            ; return information
            STA  A001
WaitFor1    LDA  03FA       ; Load frame number
            CMP  #01        ; Is it frame #1?
            BNE  WaitFor1   ; If not then loop
            JSR  GetByte    ; Get first byte of return info.
            STA  0202       ; Returned in A regiter. Location 0202
                            ; is the high byte of return information
            JSR  GetByte    ; Get next byte
            STA  0201       ; Store low byte of return information
            LDA  0205       ; Load poll request flag
            BNE  PollData   ; If set then got to special routine
            LDA  03F8       ; Load INTMPU mailbox.  This mailbox is
                            ; set if Hornby just sent a poll request
            BEQ  CheckByte  ; Not a poll request
            LDA  #FF        ; It was a poll request so set poll
            STA  0205       ; request flag and
            BNE  AfterSend  ; Jump past section that transmits info
            BEQ  AfterSend      ; since we must catch next data frame
CheckByte   LDA  0201       ; Load low byte of return info
            ORA  0202       ; Or with bits of high byte
            BEQ  AfterSend  ; If both zero then don't display or send
Display+Send LDA 0201       ; Else display low byte
```

```
                STA  2000       ; at lower two LEDs
                LDA  0202       ; Display high byte
                STA  4000       ; at middle LEDs
                JSR  SendInfo   ; And transmit both bytes over RS232
AfterSend       LDA  03FB       ; Load this computer's RDATA mailbox
                STA  6000       ; and display at higher LEDs
WaitFor4        LDA  03FA       ; Load frame number
                CMP  #04        ; Is it frame #4?
                BEQ  MainLoop   ; Yes, so got to main loop
                BNE  WaitFor4   ; No, so try again

  This routine reads 8 bits from the shift registers and puts them in A

GetByte         LDX  #00        ; Clear all registers
                LDY  #00
                LDA  #00
GetLoop         CLC             ; Clear carry bit that gets shifted into A
                TXA             ; X temporarily holds byte. Transfer to A
                ROL   A         ; then shift A left
                TAX             ; Save in x
                LDA  A001       ; Load top bit of shift registers into A
                AND  #08        ; Clear all bits but PA3
                BNE  zzz        ; If bit was high then leave low bit of X
                                ; cleared since incoming bits are inverted
                TXA             ; Else load temporary byte
                ORA  #01        ; Set low bit
                TAX             ; And save again
zzz             LDA  0200       ; Load bit PA0
                ORA  #04        ; Pulse bit PA1 low which shifts the
                STA  A001       ; shift registers one bit to the left
                ORA  #06        ; Bring it back high
                STA  A001
                INY             ; Increment number of bits we've read
                CPY  #08        ; Have we read 8 bits?
                BNE  GetLoop    ; No, so get next bit
                TXA             ; Yes, so put byte in register A
                RTS             ; And return

; This routine initializes the ACIA to 300 baud, No parity, 8 bits,
; 1 stop bit, and enables transmitter and receiver operation even though
; the receiver is not used

InitACIA        LDA  #0B        ; Mask for
                STA  C002       ; Command register
                LDA  #16        ; Mask for
                STA  C003       ; Control Register
                RTS             ; And return

; This routine sets the low bit of the low byte of return information
; to a 1 so that the MacIntosh knows that this is valid return data from
; a poll request.

PollData        LDA  0201       ; Load low byte of return info
                ORA  #01        ; Set low bit
```

```
                STA  0201       ; Save it
                STA  6000       ; Flash low byte to LEDs
                NOP             ; Next 3 NOPs were to zero out an
                NOP             ; instruction.  Just ignore them.
                NOP
                LDA  #00        ; Load zero to clear
                STA  0205       ; poll request flag
                STA  03F8       ; and INTMPU mailbox if set
                JMP  Display+Send   ; Display poll info then send it

; This routine sends the low byte then the high byte of return info
; over the RS232 line.

SendInfo        LDA  C001       ; Load Status register of ACIA
                AND  #10        ; Mask out all but Transmit Data Register
                                ; Empty bit
                BEQ  SendInfo   ; Can't send new info yet
                LDA  0201       ; Load low byte of return info
                STA  C000       ; Store in Transmit Data Register
Send1           LDA  C001       ; Wait as above
                AND  #10
                BEQ  Send1
                LDA  0202       ; Load high byte of return info
                STA  C000       ; And send it
Send2           LDA  C001       ; Wait as above
                AND  #10
                BEQ  Send2
                RTS             ; And return
```

```
REM --- Hornby Controller Program
REM --- by Mike Arena

REM --- "table" is a 2 dimensional array of strings
REM --- Each of the 9 possible computers running on the system
REM --- can have 256 (i.e. one byte) command strings
REM --- Each command string can be MAXLEN characters long
   DIM table$(9,256)
   MAXLEN = 20                'NOTE:  All files must have records of the
                              'same length so this constant should probably
                              'not be changed.
REM --- NOTE. The first element is not used in the following arrays
   DIM Speed(17)
   DIM Direction(17)
   DIM DemoCurrLoco(10)
   DIM request(10)
   ActiveLoco = 1             'Current loco being controlled by Hornby
REM --- These are the characters that Phil Dworsky's project
REM --- accepts as the keys and slide on the Hornby unit
   outval$ = "741*852=963>x<-,?HIKJNOhLDEGFBCA"
   filename$ = ""
   poll$ = "0  1  >  "        'Used to poll all computers
   manual = 1
   automatic = 0
   Mode = manual              'This determines whether you are in manual or automatic mode
   GOSUB init
   LOCATE 4,5: PRINT "Load tables and/or edit tables then";
   LOCATE 5,5: PRINT "Hit return when ready to start";

   st$ = INKEY$
   IF st$ = "" THEN GOTO st
   GOTO ManualMode

REM --- This routine waits for a software button to be pushed and grabs any
REM --- return information from the RS232
GetButton:
   dialogId = DIALOG(0)
   IF LOC(1) = 0 THEN GOTO gb1
   r1$ = INPUT$(1,1)
   r2$ = INPUT$(1,1)
   LOCATE 16,15
   TEXTFACE 1
   PRINT HEX$(ASC(r2$));
   PRINT "  ";HEX$(ASC(r1$));
   TEXTFACE 0
gb1:
   IF dialogId <> 1 THEN GOTO  GetButton
```

```
  buttonid = DIALOG(1)
  IF buttonid = 33 THEN key$ = "": GOTO gb2
  IF buttonid > 33 THEN GOTO GetButton
  key$ = MID$("abcdefghijklmnopqrstuvwxyz",buttonid,1)

  LOCATE 14,15: PRINT key$,
  RETURN

SetupManualMode:
  WINDOW 4,,(10,20)-(750,450),2
  GOSUB SetupEditScreen
  LOCATE 1,1: PRINT "To get to AUTOMATIC mode, set MODE";
  LOCATE 2,1: PRINT "to automatic then hit any 'button' on";
  LOCATE 3,1: PRINT "the screen.";
  LOCATE 14,3: PRINT "Transmit: ";
  LOCATE 16,3: PRINT "Received: ";
ManualLoop:
  GOSUB GetButton
  IF Mode = manual THEN GOTO manual1    'If Mode was changed then branch to automatic section
  WINDOW CLOSE 4
  MENU 4,0,1
  temp$ = INPUT$(LOC(1),1)                    'Clear receive buffer before continuing
  GOTO PollALL
manual1:
    IF key$ <> "" THEN GOTO man0:
      REM --- Toggle direction of train
      dir = direction(ActiveLoco)
      IF dir = 0 THEN GOTO tog1
      Direction(ActiveLoco) = 0
      send$ = "; "
      GOTO togend
    tog1:
      Direction(ActiveLoco) = 1
      send$ = "? "
    togend:
      GOSUB Transmit
      GOTO ManualLoop
    man0:
    IF key$ <> "+" AND key$ <> "-" THEN GOTO man1
      REM --- Increment ActiveLoco's speed but not past 14 or
      REM --- Decrement speed but not below 0.
      REM --- Increment and Decrement mean increase or decrease speed
      REM --- independent of Direction
      sp = Speed(ActiveLoco)
      IF sp = 14 AND key$ = "+" THEN GOTO MaanualLoop
      IF sp = 0 AND key$ = "-" THEN GOTO ManualLoop
      IF key$ = "+" THEN sp = sp + 1 ELSE sp = sp - 1
```

```
      Speed(ActiveLoco) = sp
      send$ = MID$(butval$,(33-sp),1) + "  "
      GOSUB Transmit
      GOTO ManualLoop
   man1:
   IF key$ <> "<" THEN GOTO man2
      REM --- if new loco is specified then we want to change ActiveLoco
      tnum = 1: tkey$ = ""
      GOSUB GetButton
      IF key$ <> "1" THEN GOTO loc1
         REM --- Might have two digit train number
         tkey$ = "1  "
         GOSUB GetButton
         IF key$ >= "0" AND key$ <= "6" THEN tnum = 10 ELSE tnum = 5
      loc1:
         IF tnum = 5 THEN cval = 1
         IF tnum = 10 THEN cval = 10 + VAL(key$)
         IF tnum = 1 THEN cval = VAL(key$)
         IF cval <> ActiveLoco THEN ActiveLoco = cval
         REM --- This next statement is a kludge.  It handles the case where the user
         REM --- input 'LOCO 1 LOCO ...'  If this statement was not here then the program
         REM --- would not remember the correct ActiveLoco
         IF key$ = "<" THEN send$ = "<  1  ": GOSUB transmit: GOTO man1
         send$ = "<  " + tkey$ + key$ + "  "
         GOSUB Transmit
         GOTO ManualLoop
   man2:
   IF key$ <> ";" AND key$ <> "?" THEN GOTO man3
      REM --- reset Direction for ActiveLoco
      IF key$ = ";" THEN Direction(ActiveLoco) = 0 ELSE Direction(ActiveLoco) = 1
      send$ = key$ + "  "
      GOSUB Transmit
      GOTO ManualLoop
   man3:
      REM --- Character must be either a speed control character, an arrow,
      REM --- a digit, or INERTIA character
      send$ = key$ + "  "
      GOSUB Transmit
      GOTO ManualLoop

REM --- Wait for two bytes to appear on RS232
Poll:
PollLoop1:
   IF LOC(1) = 0 THEN GOTO PollLoop1
   r1$ = INPUT$(1,1)
PollLoop2:
   IF LOC(1) = 0 THEN GOTO PollLoop2
```

```
  r2$ = INPUT$(1,1)
  RETURN
  '
PollALL:
  LOCATE 1,16 : PRINT "Polling all computers"
  PRINT #1,poll$;
  GOSUB Poll        'Get two bytes of return information
                    'NOTE: Bit 0 should be set to 1 by my project computer
                    'as a signal that this byte and the next one are the actual
                    'return information.  Theoretically, all zeroes could be returned
                    'if no computer was ready to send information.  It also
                    'serves as a protection device.  If the Mac does receive a
                    'non-zero byte but the first bit is not a 1 then my project
                    'computer must have missed the poll request so the Mac polls
                    'again.
  n1 = ASC(r1$)
  IF (n1 AND 1) = 0 THEN GOTO PollALL
  n2 = ASC(r2$)
  LOCATE 3,3 : PRINT "Received: ";
  TEXTFACE 1 : LOCATE 3,10 : PRINT HEX$(n2) " " HEX$(n1); TEXTFACE 0
  IF Mode = manual THEN GOTO ManualMode
  REM --- mow set determine which computers need servicing
  Offset = 0
  CurrMask = 64
  FOR i = 1 TO 7
    IF (n2 AND CurrMask) > 0 THEN request(i) = 1 ELSE request(i) = 0
    CurrMask = CurrMask / 2
  NEXT i
  CurrMask = 128
  FOR i = 8 TO 9
    IF (n1 AND CurrMask) > 0 THEN request(i) = 1 ELSE request(i) = 0
    CurrMask = CurrMask / 2
  NEXT i
  CurrCompNum = 1
REM --- Cycle through array of requests until there are no more
HandleRequests:
  IF CurrCompNum > 9 THEN GOTO PollALL
  IF request(CurrCompNum) = 0 THEN CurrCompNum = CurrCompNum + 1 : GOTO HandleRequests
REM --- Now poll individual computer
  LOCATE 1,16 : PRINT "Polling computer #";CurrCompNum;
  send$ = STR$(CurrCompNum)+ "  0  > "
  temp$ = INPUT$(LOC(1),1) 'Clear out buffer if any junk in it
  GOSUB Transmit
  GOSUB Poll
  n1 = ASC(r1$)
  n2 = ASC(r2$)
  LOCATE 3,3 : PRINT "Received: ";
```

```
   TEXTFACE 1 : LOCATE 3,10 : PRINT HEX$(n2)    HEX$(n1);: TEXTFACE 0
   CurrCommand = n2        'Do high byte first
   IF CurrCommand = 0 THEN GOTO NextByte
   TX$ = table$(CurrCompNum-1,CurrCommand)
   LOCATE 5,3 : PRINT "Executing command  ";
   TEXTFACE 1: PRINT HEX$(CurrCommand);"   ";TX$;SPACE$(20);: TEXTFACE 0
   CurrLine = 7
   LOCATE Currline,6
   GOSUB HandleCommand
NextByte:
   CurrCommand = n1        'Do low byte
   IF CurrCommand = 0 THEN GOTO HandleRequests
   TX$ = table$(CurrCompNum-1,CurrCommand)
   LOCATE 5,3 : PRINT "Executing command  ";
   TEXTFACE 1: PRINT HEX$(CurrCommand);"   ";TX$;SPACE$(20);: TEXTFACE 0
   CurrLine = 7
   LOCATE Currline,6
   GOSUB HandleCommand
   CurrCompNum = CurrCompNum + 1
   GOTO HandleRequests

HandleCommand:
REM --- The following does not necessarily have to be added but I am assuming
REM --- that most project computers don't know that other projects are also
REM --- controlling the trains.  So, project #1 might think that the Hornby
REM --- is currently controlling its train but project #5 might have changed the
REM --- current train while it had control.  Therefore, if the currently ActiveLoco
REM --- is different from the train number in CompCurrLoco then the new loco is
REM --- selected before the TX$ is sent.
REM --- First it checks whether to do anything at all
   IF LEN(TX$)= 0 THEN PRINT "Command string empty.";: RETURN
   IF LEFT$(TX$,1) = " " THEN PRINT "Command string empty.";: RETURN
   IF ActiveLoco = CompCurrLoco(CurrCompNum) THEN GOTO ContinueHandling
   cci = CompCurrLoco(CurrCompNum)
   AcitveLoco = cci
   IF cci > 9 THEN extra$ = "1  " : ofs = 10 ELSE extra$ = "" : ofs = 0
   digit$ = MKI$(cci - ofs)
   PRINT "Sending Initial train selection:  LOCO ";extra$;" ";digit$;" ->";
   CurrLine = CurrLine + 1
   LOCATE Currline,6
   send$ = "<  " + extra$ + digit$ + "  >  "
   GOSUB Transmit
REM --- NOTE:  This section looks very similar to the manual section.
ContinueHandling:
   position = 1
   c$ = MID$(TX$,position,1)
   WHILE position <= 20 AND c$ <> " " AND c$ <> ""
```

```
IF c$ <>    THEN GOTO cont0:
   REM --- Toggle direction of train
   dir = direction(ActiveLoco)
   PRINT "Setting direction of train ";ActiveLoco;" to ";
   IF dir = 0 THEN GOTO toggle1
   Direction(ActiveLoco) = 0
   send$ = "; "
   PRINT "REVERSE";
   GOTO toggleend
toggle1:
   Direction(ActiveLoco) = 1
   send$ = "? "
   PRINT "FORWARD";
toggleend:
   CurrLine = CurrLine + 1
   LOCATE Currline,6
   GOSUB Transmit
   GOTO ContEnd
cont0:
IF c$ <> "+" AND c$ <> "-" THEN GOTO cont1
   REM --- Increment ActiveLoco's speed but not past 14 or
   REM --- Decrement speed but not below 0.
   REM --- Increment and Decrement mean increase or decrease speed
   REM --- independent of Direction
   sp = Speed(ActiveLoco)
   IF sp = 14 AND c$ = "+" THEN GOTO ContEnd
   IF sp = 0 AND c$ = "-" THEN GOTO ContEnd
   IF c$ = "+" THEN sp = sp + 1 ELSE sp = sp - 1
   Speed(ActiveLoco) = sp
   IF c$ = "+" THEN PRINT "Incrementing speed of LOCO ";ActiveLoco;" to ";sp;SPACE$(20);
   IF c$ = "-" THEN PRINT "Decrementing speed of LOCO ";ActiveLoco;" to ";sp;SPACE$(20);
   CurrLine = CurrLine + 1
   LOCATE Currline,6
   send$ = MID$(butval$,(33-sp),1) + " "
   GOSUB Transmit
   GOTO ContEnd
cont1:
IF c$ <> "<" THEN GOTO cont2
   REM --- if new loco is specified then we want to change ActiveLoco
   mult = 1
   position = position + 1
   IF position > 20 THEN LOCATE 12,1 : PRINT "Malformed string!!!";: GOTO ContEnd
   c$ = MID$(TX$,position,1)
   IF c$ <> "1" THEN GOTO loco1
      REM --- Might have two digit train number
      IF position+1> 20 THEN GOTO loco1
      tempc$ = MID$(TX$,position+1,1)
```

```
    IF tempc$ >= "0" AND tempc$ <= "6" THEN mult = 10
  loco1:
    PRINT "LOCO ";c$;" ";
    cval = VAL(c$)
    IF mult = 10 THEN cval = (cval*10) + VAL(tempc$)
    IF cval <> ActiveLoco THEN ActiveLoco = cval : CompCurrLoco(CurrCompNum) = cval
    REM --- We have grabbed loco character and next one so only send those two
    REM --- If we did read tempc$, then just leave it for next iteration
    REM --- since we didn't actually grab it, we just looked at it
    send$ = "< " + c$ + " "
    GOSUB Transmit
    GOTO ContEnd
cont2:
IF c$ <> ";" AND c$ <> "?" THEN GOTO cont3
  REM --- reset Direction for ActiveLoco
  IF c$ = ";" THEN Direction(ActiveLoco) = 0 ELSE Direction(ActiveLoco) = 1
  IF c$ = ";" THEN PRINT "REVERSE"; ELSE PRINT "FORWARD";
  CurrLine = CurrLine + 1
  LOCATE Currline,6
  send$ = c$ + " "
  GOSUB Transmit
  GOTO ContEnd
cont3:
  REM --- Character must be either a speed control character, an arrow,
  REM --- a digit, or INERTIA character
  IF c$ <> "=" AND c$ <> ">" THEN cont31
    IF c$ = "=" THEN PRINT "<-"; ELSE PRINT "->";
    CurrLine = CurrLine + 1
    LOCATE Currline,6
    GOTO cont3end
  cont31:
    IF c$ < "0" OR c$ > "9" THEN GOTO cont32
    PRINT c$" ";
    GOTO cont3end
  cont32:
    IF c$ <> ":" THEN GOTO cont33
    PRINT "Inertia ";
    GOTO cont3end
  cont33:
    PRINT "Set LOCO #";ActiveLoco;" to speed ";33-INSTR(butval$,c$);
    CurrLine = CurrLine + 1
    LOCATE Currline,6
  cont3end:
  send$ = c$ + " "
  GOSUB Transmit
ContEnd:
    position = position + 1
```

```
    IF position <= 20 THEN c$ = MID$(TX$,position,1
  WEND
  RETURN

REM --- Transmit send$ over RS232
Transmit:
  l = LEN(send$)
  FOR i = 1 TO l
    PRINT #1,MID$(send$,i,1);
  NEXT i
  RETURN

REM --- Initialize the menus
Init:
  TEXTFONT 2
  TEXTSIZE 12
  TEXTMODE 0

  REM --- Setup menus and variables
  MENU 1,0,1,"Quit"
  MENU 1,1,1,"Yes"

  MENU 2,0,1,"Edit"
  MENU 2,1,1,"Table"

  MENU 3,0,1,"File"
  MENU 3,1,1,"Load"
  MENU 3,2,1,"Save"

  MENU 4,0,1,"Mode"
  MENU 4,1,1,"Manual"
  MENU 4,2,1,"Automatic"

  MENU 5,0,0,""
  ON MENU GOSUB HandleMenu
  MENU ON

  FOR i = 1 TO 9
    request(i) = 0
    CompCurrLoco(i) =
    Direction(i) = 1
    Speed(i) = 0
  NEXT i
  FOR i = 10 TO 16
    Direction(i) = 1
    Speed(i) = 0
  NEXT i
```

```
REM --- These parameters are burned into my EPROM
   OPEN "COM1:300,n,8,1" AS #1 LEN=2000
   RETURN

HandleMenu:
   MENU OFF  'Disable all menus while handling menus
   m = MENU(0)
   menuitem = MENU(1)
   IF m = 1 THEN END                    'got QUIT command
   IF m = 3 THEN GOTO DoFile            'got FILE command
   IF m = 2 THEN menu1                  'If not MODE selection then go to EDIT section
   IF menuitem = 1 THEN Mode = manual ELSE Mode = automatic
   MENU 4,0,1
   GOTO MenuReturn
menu1:
   WINDOW 2,,(10,20)-(750,450),2
   tempmode = Mode : Mode = automatic   'Temporarily set Mode so that SetupEdit Screen
   GOSUB SetupEditScreen                'will draw all the buttons
   Mode = tempmode
   GOSUB DoEdit
   WINDOW CLOSE 2
   MENU 1,0,1

MenuReturn:
   MENU ON
   RETURN

REM --- First determine whether to LOAD or SAVE
DoFile:
   IF menuitem = 2 THEN GOTO SaveFile

REM --- Uses BASIC's "files" command to bring up the file menu
REM --- Simply saves 256 strings of length MAXLEN.  User is prompted
REM --- for which table to save
LoadFile:
   filename$ = FILES$(1)
   IF filename$ = "" THEN MENU 2,0,1: GOTO MenuReturn
   OPEN filename$ AS #2 LEN = MAXLEN
   FIELD #2, MAXLEN AS buffer$
   GOSUB GetCompNum
   FOR i = 0 TO 255
      GET #2,i+1
      table$(bikid,i) = buffer$
   NEXT i
   CLOSE #2
   MENU 2,0,1
```

```
  GOTO MenuReturn

REM --- First the "files" box appears.  Select a file and then hit "OPEN"
REM --- If you want to create a new file then hit "CANCEL"
REM --- A new "files" box appears where you can type in the name
REM --- If you don't want to create a file either then hit "CANCEL"
SaveFile:
  filename$ = FILES$(1)
  IF filename$ <> "" THEN GOTO DoSave
  filename$ = FILES$(0)
  IF filename$ = "" THEN MENU 2,0,1: GOTO MenuReturn
DoSave:
  GOSUB GetCompNum
  OPEN filename$ AS #2 LEN = MAXLEN
  FIELD #2, MAXLEN AS buffer$
  FOR i = 0 TO 255
    LSET buffer$ = table$(blkid,i)
    PUT #2,i+1
  NEXT i
  CLOSE #2
  MENU 2,0,1:
  GOTO MenuReturn

REM --- Draws layout of Hornby controller keypad and speed slide
SetupEditScreen:
  RESTORE
  LOCATE 7,33 : PRINT "SPEED";
  FOR i=1 TO 12
    READ x,y,nam$
    BUTTON i,1,nam$,(x,y)-(x+30,y+15)
  NEXT i
  FOR i=13 TO 18
    READ x,y,nam$
    BUTTON i,1,nam$,(x,y)-(x+60,y+15)
  NEXT i
  FOR i=19 TO 33
    READ x,y,nam$
    BUTTON i,1,nam$,(x,y)-(x+20,y+12)
  NEXT i
  FOR i= 34 TO 38
    READ x,y,nam$
    BUTTON i,1,nam$,(x,y)-(x+70,y+25)
  NEXT i
  READ x,y,nam$
  BUTTON 39,1,nam$,(x,y)-(x+60,y+15)
  RETURN
```

```
REM --- Gets the number of the array entry to be edited
GetCommand:
   WINDOW 3,,(150,50)-(350,100),2
CommLoop:
   LOCATE 1,2
   PRINT "Enter 2 digit command in HEX";
   LOCATE 2,10 : INPUT comm$
   comm$ = UCASE$(comm$)
   IF LEN(comm$) <> 2 THEN CommLoop
   ld$ = LEFT$(comm$,1)
   rd$ = RIGHT$(comm$,1)
   ln = ASC(ld$) - 48
   IF ln > 9 AND ln < 16 THEN GOTO CommLoop
   IF ln > 16 THEN ln = ln - 7
   IF ln < 0 OR ln > 15 THEN GOTO CommLoop
   rn = ASC(rd$) - 48
   IF rn > 9 AND rn < 16 THEN GOTO CommLoop
   IF rn > 16 THEN rn = rn - 7
   IF rn < 0 OR rn > 15 THEN GOTO CommLoop
   CommNum = 16*ln + rn
   IF CommNum = 0 THEN GOTO CommLoop
   WINDOW CLOSE 3
   RETURN

REM --- Gets the number of the table for either "EDIT", "LOAD", or "SAVE"
GetCompNum:
   WINDOW 3,,(150,50)-(370,100),2
CompLoop:
   LOCATE 1,2
   PRINT "Enter computer's BLKID  (1-9)";
   LOCATE 2,10 : INPUT blkid
   IF blkid < 1 OR blkid > 9 THEN CompLoop
   blkid = blkid - 1
   WINDOW CLOSE 3
   RETURN

REM --- Processes all the buttons
REM --- Command strings can be MAXLEN characters long
REM --- When finished entering "keystroke" use "OK" to save the newly
REM --- entered string in the table or use "CANCEL" to enable the
REM --- "DONE" and "COMMAND" buttons.  (NOTE: while entering a string,
REM --- the "DONE" and "COMMAND" buttons are disabled so that you can't
REM --- quit editing or select a new command byte until you finished
REM --- with the present command.)  Use the "DELETE" button while you
REM --- are entering "keys" in the string to erase the last character
REM --- entered.  Use the "COMMAND" button to select a new table entry.
REM --- Use "DONE" to quit editing.
```

```
DoEdit:
   CommNum = 1 : comm$ = "01"      'default to second element of array
                                   '00 is not an allowed command
   GOSUB GetCompNum
   TEXTSIZE 18
   LOCATE 1,1 : PRINT "Editing table for";
   LOCATE 2,1 : PRINT "Computer #";blkid+1;
   TEXTSIZE 12
   LOCATE 14,1 : PRINT "Current string for command ";
   TEXTFACE 1 : LOCATE 14, 21 : PRINT comm$": "; : TEXTFACE 0
   LOCATE 14,28 : PRINT table$(blkid,CommNum);
   LOCATE 16,1 : PRINT "New string: ";
   LOCATE 16,12
   newcomm$ = ""
   numkeys = 0
REM ---
EditLoop:
   dialogid=DIALOG(0)
   IF dialogid<>1 THEN EditLoop
   buttonid=DIALOG(1)
   IF buttonid > 33 AND buttonid < 39 THEN ProcessCommand
   BUTTON 37,0    'Turn off "DONE" and "COMMAND" buttons
   BUTTON 36,0
   IF numkeys >= MAXLEN THEN BEEP : GOTO EditLoop
   numkeys = numkeys + 1
   IF buttonid = 39 THEN key$ = "~" : GOTO ed1
   key$ = MID$(butval$,buttonId,1)   'Find corresponding byte to send Hornby
ed1:
   PRINT key$;
   newcomm$ = newcomm$ + key$
   GOTO EditLoop

REM --- button hit was not a "key" so it must be an editing command
ProcessCommand:
   IF buttonid > 34 THEN label1                    'Branch if not "OK"
      table$(blkid,CommNum) = newcomm$
      LOCATE 14,28 : PRINT table$(blkid,CommNum);
      LOCATE 16,12 : PRINT table$(blkid,CommNum);
      BUTTON 36,1
      BUTTON 37,1
      GOTO EditLoop
label1:
   IF buttonid > 35 THEN label2                    'Branch if not "CANCEL"
      BUTTON 36,1
      BUTTON 37,1
      GOTO EditLoop
label2:
```

```
  IF buttonId > 36 THEN label3                    'Branch if not "DONE"
    RETURN
label3:
  IF buttonId > 37 THEN label4                    'Branch if not "COMMAND"
    GOSUB GetCommand
    LOCATE 14,1 : PRINT "Current string for command ";
    TEXTFACE 1 : LOCATE 14, 21 : PRINT comm$": "; : TEXTFACE 0
    LOCATE 14,28 : PRINT table$(blkid,CommNum);: PRINT SPACE$(25);
    LOCATE 16,1 : PRINT "New string: ";
    LOCATE 16,12 : PRINT SPACE$(25);
    LOCATE 16,12
    newcomm$ = "" : numkeys = 0
    GOTO EditLoop
label4:
  IF numkeys = 0 THEN GOTO EditLoop               'Nothing to "DELETE"
  numkeys = numkeys - 1
  LOCATE 16,12
  IF numkeys > 0 THEN label5
  newcomm$ = "" : PRINT SPACE$(25);
   LOCATE 16,12
   GOTO EditLoop
label5:
  newcomm$ = LEFT$(newcomm$,numkeys)
  PRINT newcomm$;
  GOTO EditLoop


REM --- x,y coordinate of BUTTON,  title of BUTTON
  DATA 10,110,7
  DATA 10,130,4
  DATA 10,150,1
  DATA 10,170,0
  DATA 50,110,8
  DATA 50,130,5
  DATA 50,150,2
  DATA 50,170,<-
  DATA 90,110,9
  DATA 90,130,6
  DATA 90,150,3
  DATA 90,170,->
  DATA 130,110,Inertia
  DATA 130,130,LOCO
  DATA 130,150,INC Spd
  DATA 130,170,DEC Spd
  DATA 210,150,Reverse
  DATA 210,170,Forward
  DATA 300,10,14
```

```
DATA 300,22,13
DATA 300,34,12
DATA 300,46,11
DATA 300,58,10
DATA 300,70,9
DATA 300,82,8
DATA 300,94,7
DATA 300,106,6
DATA 300,118,5
DATA 300,130,4
DATA 300,142,3
DATA 300,154,2
DATA 300,166,1
DATA 300,178,0
DATA 370,10,Ok
DATA 370,40,Cancel
DATA 370,70,Done
DATA 370,100,Command
DATA 370,130,Delete
DATA 210,130,Toggle

REM --- End of program
```