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A General-Purpose Microprocessor-Based Control Chassis

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A GENERAL-PURPOSE MICROPROCESSOR-BASED CONTROL CHASSIS

by

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ABSTRACT

The objective of the Pion Generation for Medical Irradiations (PIGMI) program at the Los Alamos Scientific Laboratory is to develop the technology to build smaller, less expensive, and more reliable proton linear accelerators for medical applications. For this program, we developed a powerful, simple, inexpensive, and reliable control and data acquisition system. The system has a NOVA 3D computer with a real time disk-operating system (RDOS) that communicates with distributed microprocessor-based controllers which directly control data input/output chassis. At the heart of the controller is a microprocessor crate which was conceived at the Fermi National Accelerator Laboratory. We applied this idea to the design of the hardware and software of the controller.

I. INTRODUCTION

Microprocessors are used widely in research and development applications. Their value in accelerator control was sensed early at the Fermi National Accelerator Laboratory (FNAL) where an extremely adaptable, modular microprocessor-based controller was conceived.¹

The main advantages of the controller are its modularity and interfaceability. For example, one 115- by 165-mm board has 64 binary data lines and 16 handshake lines. These lines are divided into four identical ports. Each port has 16 binary data lines that can be programmed as inputs or outputs, and 4 handshake lines, 2 of which can be programmed as inputs or outputs and 2 that are inputs only. Peripheral devices interface to this board, called a peripheral interface adapter (PIA) board, via four 26-conductor ribbon cables that have "smash-on," solderless connectors.

The objective of the Pion Generation for Medical Irradiations (PIGMI) project at the Los Alamos Scientific Laboratory (LASL) is to demonstrate the technology required to build small, high-energy proton linear accelerators (linacs) for use in generating negative pions for cancer therapy at larger medical centers. Because of the need for a flexible, easy-to-use controller to acquire data from and to control experiments on prototype structures, we developed the microprocessor chassis (MPC) using the basic concept of the FNAL system.

Many of the basic modules for the MPC are commercially available.* Additional modules have been designed and are described in this report. Although in this report we describe a system-type controller, the modules can be used in smaller configurations for dedicated applications and/or single installations.²

*OMNIBYTE Corp., 245 W. Roosevelt Rd., West Chicago, Illinois.

II. THE MPC

The MPC (Fig. 1a) is 216 mm high, 482 mm wide, and 508 mm deep. The main operating part of the MPC is the microprocessor crate, a 16-slot board cage with a printed circuit (PC) board backplane. The microprocessor, memory, and various interface boards plug into this crate. The basic arrangement of the crate is described in Ref. 1. The position of the crate allows access to the boards from behind the MPC. The power supplies, mounted beside and in front of the crate, connect to a terminal strip that terminates the power supply wires from the backplane.

Figure 1b shows a locking toggle switch on the lower left front panel for on/off control of the power supplies. The ac-power indicator lights are directly above the switch. There is a reset button on the upper left-hand corner of the front panel.

At the top of the front panel is a four-digit hexadecimal (hex) light-emitting diode (LED) display. All front panel indicators and switches are accessed through the controller software. Below the hex display are eight discrete LEDs and eight toggle switches. The software controls the LEDs, which operate independently from the toggle switches. The toggle switches set data lines high or low. The data lines also are accessed through the controller software. The LEDs and toggle switches are mounted on one binary switch/LED board. Below the toggle switches is a four-digit hex thumbwheel switch, which is used to enter hex-encoded data into the controller. The hex switch and hex display can be used with binary-coded decimal (BCD) instead of hex format for operators who are more familiar with the BCD format.

The final interface is the push-button/LED board. The toggle switches function like sense switches; they cannot be reset by the microprocessor unit (MPU). The push-button/LED interface board was designed to be used in two different modes. One is the set-reset mode, in which a single push of the button sets a condition. The MPU responds to and resets this condition, whether or not the button has been released. A second mode is the duration-of-push mode. Here a push of the button sets the condition, but the condition cannot be reset until the button is released. The first option generally is used for tasks that run independently to completion. The latter option is used to control the duration of a task.

For example, pushing a button opens a valve continuously until a certain pressure is read on a meter. When the button is released, the valve remains in its position, and the pressure remains constant. The software controls the LEDs on the board, regardless of the status of the switches.

Note that the front panel has no labels for the switches and LEDs. This is because the functions of these devices are dynamic; that is, the functions can be redefined by whatever task is running at that time. We describe this redefining in more detail in Sec. III. For dedicated applications, switch and LED labels probably would be used.

Long cables attach to the 25-pin D connectors on the back panel (Fig. 1c). The D connectors attach to the PIA boards with short lengths of ribbon cable, which can be easily connected to and disconnected from the PIA board. The power supply test points on the lower left-hand side of the rear panel allow the supply voltages to be monitored without removing the MPC from a rack. A fuse, an ac-power-present light, and a power connector that is an integral part of an electromagnetic interference (EMI) filter are mounted on the rear panel. Shown on the upper right-hand side of the rear panel are three Lemo (K-loc) sockets, one of which is an output port whose state is controlled by the software. The other two sockets can be used as inputs to interrupt the MPU. One, a maskable interrupt line, responds to a positive or negative edge, depending on how it is programmed. The other, a nonmaskable interrupt line, is always active and responds to a high-to-low transition.

The front panel boards are interfaced to the MPU using the standard PIA board. Because the cables can be disconnected at either end, the front panel boards can be removed easily for maintenance.

The hex display board receives its data from the MPU via a dedicated PIA port whose 16 data lines are programmed as outputs. The 16 lines are divided into 4 groups of 4 and each group connects to one of 4 TIL 311 displays, which have their own decoding logic. The hex display board also has two inputs that can be programmed to interrupt the MPU on either positive or negative transitions of signals driving these inputs. These inputs are connected to the CB1 and CA1 lines. One other line, CA2, can output pulses to an external device under software control. The CA2 and CA1 lines are connected to the rear-panel Lemo sockets with RG-174 cables.

Fig. 1.
The MPC. (a) top, (b) front, (c) rear.

The binary switch/LED board has eight LEDs that are driven by high-current drivers. Thus, one can also use the board as an interface to relays or to other high-current devices. The signals that drive the LEDs come in on 8 of the 16 data wires that come from the PIA board. The toggle switches connect the other eight input lines to the 5-V bus or to ground. The CA2 and CB2 lines from the PIA are buffered through 50- Ω line drivers and are available as outputs on the board. There are two input lines connected to the trigger gate of an SN74221 dual one shot. A low-to-high transition on either input of the one shot creates a 1- μ s pulse on the CA1 or CB1 line.

The hex switch interface boards supply four sets of four hex-encoded lines to the PIA. The switch connects the lines to ground or to the 5-V bus to code them properly.

The push-button/LED board circuitry accepts programming instructions that determine which of the buttons are used in the set-reset mode and which are used in the duration-of-push mode. Pushing the buttons used in the set-reset mode clocks an edge-sensitive flip-flop. This action is transmitted to one of the eight input lines and to the CA1 handshake line of the PIA. If the PIA has been programmed to be sensitive to a transition on the CA1 input, it

transmits an interrupt to the MPU. By another method, the MPU polls the data lines to check whether any of them are set. In either case, the MPU, through the PIA, can asynchronously reset the flip-flop, whether or not the button is still depressed. In the duration-of-push mode, the initialization of the board gates the switch status instead of the outputs of the flip-flops onto the data lines. Again, the pushing of a switch may or may not cause the MPU to be interrupted, but the computer cannot reset the action. Because this push-button/LED board has not been reported before, a schematic and a software listing of a diagnostic program for it are provided in Appendix A.

III. INTERACTIVE FRONT PANEL AND TELETYPE MONITOR

We developed a versatile monitor program that can perform tasks in a loop and can service an ASCII-encoded keyboard terminal (KBT).

The basic loop in all systems performs two functions. The first function checks whether a button has been pushed; if so, the task assigned to that push button is executed. The second function is executed

if buttons 6 and 7 are pushed within 50 ms of each other; when this occurs, the value entered on the toggle switches is stored in the memory address specified on the hex switch. To accomplish the first function, a vector, or two random access memory (RAM) locations, are defined for each push button. These vectors contain the address of the task currently assigned to a button. (Appendix B lists the button numbers and associated RAM locations that contain the vectors.) When a button is pushed, program control jumps to the subroutine pointed to by that button's vector, executes the subroutine, and returns to the monitor loop. A button task is changed simply by putting a different subroutine address in the proper vector location. Either software reassignment of the vector or use of a vector assignment feature of the front panel can change the task. To use the latter feature, one must dial the new task address on the hex switch, raise the toggle switch that corresponds to the button to be reassigned, and push button 8, the lower push button. Using this feature assigns the address on the hex switch to the button designated by the toggle switch. Button 8 is assigned this feature at initialization, although its own vector cannot be reassigned by using the feature. However, a new vector can be assigned to button 8 by the software.

In addition to the monitor's two basic functions, other functions can be added to every loop while it is checking for a pushed button or after a pushed button has been detected, but before the associated task is executed. Figure 2 shows where these functions can be added. The loop tasks have RAM vectors, which are similar to the push-button RAM vectors (Appendix B). To add functions to the loop, store the address of the subroutine that provides the function in the proper vector.

Two resident functions that can be added to any loop are a function that displays memory in the hex display and a function that provides an activity monitor. The first function displays in the hex display the data in the memory address specified by the hex switch and also the data in the next sequential memory location. The lights above the toggle switches are the activity monitor. Their rate of movement reflects the activity of the system. Between each move of the lights, the monitor loop is executed 1024 times.

The standard front panel monitor software is used in each MPC of the PIGMI control system. The

Fig. 2.
Front panel monitor flow chart.

software is expanded to perform all necessary functions in a particular system. For example, the MPU that monitors the console has features in the main loop that service the touch panel, character scope, trackball, keypad, 611 storage scope, NOVA-MPC communications, etc.

Listing 1 in Appendix C is an example of the basic front panel monitor software. The desired features are added to the basic loop lines 29 to 35 in the subroutine SUB (lines 36-39). The routine to service a pushed button is in lines 65-96. This basic software also includes routines to

- initialize button and loop vectors (lines 99-118),
- initialize the front panel boards (lines 119-145),
- reset the push buttons (lines 146-150),
- display data at the memory address dialed in the hex switch (lines 158-161),
- use button 8 to reassign the button functions (lines 164-177),
- display activity lights (lines 180-191), and
- delay microseconds or milliseconds (lines 196-215).

System access to a KBT is sometimes desirable, especially during the developmental stages. Therefore, we made the KBT monitor (KBTMON) used in the software development system coresident

with the MPC system software. To merge the two monitors, four guidelines were considered.

- (1) Usually, the panel monitor loop should not be disabled for more than a few milliseconds.
- (2) The KBTMON software will be standard in all systems.
- (3) The tape load function of KBTMON should not be degraded; that is, tapes should dependably load at 1200 baud.
- (4) The merger should be done in a straightforward manner that requires minimal software communication between the monitors.

A straightforward merger provides that the push-button monitor (PBMON) be serviced on each entry into an input/output (I/O) routine of KBTMON. With a microprocessor clock rate of 1 MHz the delay between PBMON loops is 75 μ s when no entry is made from the KBT, 100 μ s when an entry is processed, and variable when a memory zero or transfer function is executed.

Through this merger, PBMON is intact and completely independent of KBTMON, and KBTMON transfers control to PBMON instead of wasting time while waiting for I/O timing. For example, a KBT operating at 300 baud transmits a character every 3.3 ms at its fastest rate. The input loop is 100 μ s long. Instead of waiting in a loop for the next input, KBTMON transfers control to PBMON, which usually returns control to KBTMON in less than 200 μ s. When operating at 300 baud, the asynchronous communications interface adapter (ACIA) board can be neglected for ~6.6 ms without losing KBT input data. Losing data, which rarely happens, is not

critical because the loss is signaled to the operator, who then re-enters the data. A complete listing and documentation of the adapted KBTMON is given in Appendix D.

In this scheme, KBTMON must know the initialize and loop vectors of PBMON (Appendix B). Because PBMON is independent of KBTMON, one can use PBMON, without modification, with any type of KBT monitor. Only minor modification of the KBT monitor is required.

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1. R. W. Goodwin, R. F. Kocanda, and M. F. Shea, "A Method for Implementing Microprocessor Controlled Systems," IEEE Trans. Nucl. Sci. NS-23, No. 1, 297-300 (1976).
2. D. J. Liska, J. N. Levitt, J. K. Halbig, and L. B. Dauelsberg, "A Clinical Servo System for Shifting the Range of Pion Beams," IEEE Trans. Nucl. Sci. NS-24, No. 3, 1046-1047 (1977).

APPENDIX A

PUSH-BUTTON LED BOARD SCHEMATIC AND SOFTWARE LISTING

See Fig. A-1 inside pocket at the back for schematic.

```

PAGE 001  PUSHB
00001      NAM      PUSHB
00002      *
00003      *      PUSHBUTTON TEST PROGRAM
00004      *
00005      *      THIS PROGRAM TESTS THE PUSHBUTTON CARD.
00006      *
00007      *      ENTERING AT $A200 TESTS THE PUSHBUTTONS
00008      *      IN THE DURATION-OF-PUSH MODE. AS LONG
00009      *      AS A BUTTON IS PUSHED ITS CORRESPONDING
00010      *      LIGHT IS LIT.
00011      *
00012      *      ENTERING AT $A202 CHECKS THE SET-RESET
00013      *      MODE. WHEN A BUTTON PUSH IS DETECTED THE
00014      *      CORRESPONDING LIGHT IS TURNED ON AND
00015      *      REMAINS ON UNTIL ANOTHER BUTTON IS PUSHED AT
00016      *      WHICH TIME THAT BUTTON'S CORRESPONDING LIGHT
00017      *      IS TURNED ON.
00018      *
00019      8106  PUSHB  EQU    $8106
00020      *
00021  A200      DRG    $A200
00022  A200 20 25  VDUR  BRA    DUR      MAKE PB DURATION
00023      *
00024  A202 CE 0000  SETRST LDX    #$0000  SET-RESET MODE
00025  A205 FF 810E      STX    PUSHB+8  CONFIGURE PIA
00026  A208 CE 00FF      LDX    #$00FF  A-SIDE INPUT
00027  A20B FF 8106      STX    PUSHB    B-SIDE OUTPUT
00028  A20E CE 3C3C      LDX    #$3C3C  BRING CA2, CB2 HIGH
00029  A211 FF 810E      STX    PUSHB+8
00030  A214 86 FF      LDA  A    #$FF    CONFIGURE CARD
00031  A216 B7 8107      STA  A    PUSHB+1  FOR SET-RESET
00032  A219 CE 3C34      LDX    #$3C34  LATCH IN SET-RESET
00033  A21C FF 810E      STX    PUSHB+8
00034  A21F 7F A000      CLR     FLAG    USED TO DISPLAY
00035  A222 7F 8107      CLR    PUSHB+1  CLEAR PUSHBUTTON FF'S
00036  A225 20 25      BRA     TEST
00037      *
00038  A227 CE 0000  DUR  LDX    #$0000  CONFIGURE PB FOR DURATION
00039  A22A FF 810E      STX    PUSHB+8
00040  A22D CE 00FF      LDX    #$00FF
00041  A230 FF 8106      STX    PUSHB
00042  A233 CE 3C3C      LDX    #$3C3C  BRING CA2,CB2 HIGH
00043  A236 FF 810E      STX    PUSHB+8
00044  A239 86 00      LDA  A    #$00    CONFIGURE CARD
00045  A23B B7 8107      STA  A    PUSHB+1  FOR DURATION
00046  A23E CE 3C34      LDX    #$3C34  LATCH IN DURATION
00047  A241 FF 810E      STX    PUSHB+8
00048  A244 86 01      LDA  A    #$01
00049  A246 B7 A000      STA  A    FLAG    USED TO DISPLAY
00050  A249 7F 8107      CLR    PUSHB+1  CLEAR PUSHBUTTONS
00051      *
00052  A24C 7D A000  TEST  TST     FLAG    RESET OR DURATION?
00053  A24F 26 14      BNE     PBUT1  DURATION
00054  A251 B6 8106      LDA  A    PUSHB    ANY BUTTONS PUSHED?
00055  A254 27 F6      BEQ     TEST    NO, START LOOP AGAIN
00056  A256 C6 34      LDA  B    #$34    RESET PUSHBUTTONS
00057  A258 F7 810E      STA  B    PUSHB+8
00058  A25B C6 3C      LDA  B    #$3C

```

```

PAGE 002  PUSHB
00059 A25D F7 810E      STA B  PUSHB+8
00060 A260 B7 8107      STA A  PUSHB+1  DISPLAY VALUE IN PB LIGHTS
00061 A263 20 E7        BRA  TEST    CONTINUE LOOKING FOR PUSH
00062 A265 B6 8106 PBT1 LDA A  PUSHB    READ PUSHBUTTONS
00063 A268 B7 8107      STA A  PUSHB+1  DISPLAY IF NOW PUSHED
00064 A26B 20 DF        BRA  TEST    CONTINUE LOOKING FOR PUSH
00065
00066 A000              *
00067 A000 0001      FLAG  ORG  $A000
00068              *      RMB  1      SCRATCH RAM
00069              END
TOTAL ERRORS 00000

```

APPENDIX B

VECTORS

TABLE B-I

SYSTEM VECTORS

Vector*	PBMON Location (hexadecimal)
Button-1 task address	A1E0
Button-2 task address	A1E2
Button-3 task address	A1E4
Button-4 task address	A1E6
Button-5 task address	A1E8
Button-6 task address	A1EA
Button-7 task address	A1EC
Button-8 task address	A1EE

*On restart, these button vectors default to the tasks described by vectors \$F003—\$F017 under PBMON vectors.

TABLE B-II

LOOP VECTORS

PBMON Location	Loop Addition Vectors* (hexadecimal)
A1F0	First loop addition
A1F2	Second loop addition

*On restart, these vectors default to the tasks described in Fig. 2 (in text).

TABLE B-III
PBMON VECTORS

<u>Location</u>	<u>Name</u>	<u>Description</u>
F000	VPLOOP	Goes to beginning of monitor loop
F003	VBUT1	Goes to button-1 task
F006	VBUT2	Goes to button-2 task
F009	VBUT3	Goes to button-3 task
F00C	VBUT4	Goes to button-4 task
F00F	VBUT5	Goes to button-5 task
F012	VBUT6	Goes to button-6 task
F015	VBUT7	Goes to button-7 task
F018	VINALL	Initializes all devices, vectors used in PBMON
F01B	VIPANL	Initializes only front panel PIAs
F01E	VRSX11	Produces activity lights
F021	VMILLI	Delay (X) milliseconds
F024	VMICRO	Delay (X) microseconds

TABLE B-IV
KBTMON VECTORS

<u>Location (hexadecimal)</u>	<u>Name</u>	<u>Description</u>
FC00	VENTR	Initializes ACIA, RAM, goes to TTY control loop
FC03	VINHEX	Checks whether character is valid hex character
FC06	VBADDR	Inputs 4-digit address
FC09	VOTCH	Outputs 1 character
FC0C	VOT2H	Outputs 2 characters
FC0F	VOT4HS	Outputs 4 characters and 1 space
FC12	VOT2HS	Outputs 2 hex characters and 1 space
FC15	VOTS	Outputs 1 space
FC18	VPDAT1	Prints data string
FC1B	VPDATA	Prints carriage return, line feed, data string
FC1E	VPCRLF	Prints carriage return, line feed
FC21	VPSTK	Prints stack on interrupt
FC24	VBYTE	Inputs 1 byte
FC27	VBINH	No action
FC2A	VINCH	Inputs 1 character

APPENDIX C

LISTING 1

LASL Identification No. LP-1067 (TTYMON)

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---
PAGE 001  PBMON
00001
00002
00003
00004
00005
00006
00007
00008
00009
00010 F000      DRG      $F000
00011      F000      VORG      EQU      *
00012 F000 7E F027 VPLDOP JMP      PBLOOP
00013 F003 7E F117 VBUT1  JMP      WINK
00014 F006 7E F117 VBUT2  JMP      WINK
00015 F009 7E F117 VBUT3  JMP      WINK
00016 F00C 7E F117 VBUT4  JMP      WINK
00017 F00F 7E F117 VBUT5  JMP      WINK
00018 F012 7E F117 VBUT6  JMP      WINK
00019 F015 7E F117 VBUT7  JMP      WINK
00020 F018 7E F083 VINALL JMP      INALL      INIT. VECTORS AND F. PANEL
00021 F01B 7E F08F VIPANL JMP      IPANEL     INIT. FRONT PANEL
00022 F01E 7E F142 VRX11  JMP      RSX        DISPLAY ACTIVITY LIGHTS
00023 F021 7E F16F VMILLI JMP      DMILLI     DELAY MILLISECND
00024 F024 7E F15B VMICRO JMP      DMICRO     DELAY MICROSECND
00025
00026
00027
00028
00029      F027      PBLOOP EQU      *
00030 F027 FE A1F0      LDX      VSUB1      DEFAULTS TO SUB1
00031 F02A AD 00      JSR      0,X
00032 F02C B6 8106      LDA      A        PUSHB      ANY BUTTONS PUSHED?
00033 F02F 27 02      BEQ      PBLP1
00034 F031 8D 08      BSR      PBSER      SERVICE PUSHED BUTTON
00035 F033 39      PBLP1 RTS
00036      F034      SUB1  EQU      *        LOOP SUBROUTINE
00037 F034 BD F11D      JSR      PEEK      DISPLAY MEMORY
00038 F037 BD F142      JSR      RSX      DISPLAY FLASHING LIGHTS
00039 F03A 39      RTS
00040
00041
00042
00043
00044
00045      8100      HEXLT  EQU      $8100      HEX LED LIGHTS
00046      8102      HEXSW  EQU      $8102      HEX SWITCH
00047      8104      TGGGL  EQU      $8104      TOGGLE SWITCHES
00048      8106      PUSHB  EQU      $8106      PUSHBUTTONS
00049
00050      A1E0      VCTR1  EQU      $A1E0
00051      A1E2      VCTR2  EQU      $A1E2
00052      A1E4      VCTR3  EQU      $A1E4
00053      A1E6      VCTR4  EQU      $A1E6
00054      A1E8      VCTR5  EQU      $A1E8
00055      A1EA      VCTR6  EQU      $A1EA
00056      A1EC      VCTR7  EQU      $A1EC
00057      A1EE      VCTR8  EQU      $A1EE
00058      A1F0      VSUB1  EQU      $A1F0

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```

---
PAGE 002 PBDON
00059 A1F2 VSUB2 EQU $A1F2
00060 A1F4 RXSAVE EQU $A1F4
00061 A1F6 DTIME EQU $A1F6
00062 A1F8 ASAVE EQU $A1F8
00063
00064
*
* SERVICE BUTTON PUSHED
00065 F03B B7 A1F8 PBSER STA A ASAVE SAVE BUTTON PUSHED
00066 F03E BD F10C JSR RSTPB RESET PUSHBUTTONS
00067 F041 FE A1F2 LDX VSUB2
00068 F044 AD 00 JSR 0,X LOOP ADDITION?
00069 F046 B6 A1F8 LDA A ASAVE GET BUTTON PUSHED
00070 F049 85 60 BIT A #$60 CHECK FOR 6 OR 7 PUSHED
00071 F04B 27 1E BEQ PBM0 NO
00072 F04D CE 0032 LDX #50
00073 F050 BD F16F JSR DMILLI DELAY FOR 50 MILLISEC.
00074 F053 B6 8106 LDA A PUSHB READ BUTTONS AGAIN
00075 F056 36 PSH A
00076 F057 BD F10C JSR RSTPB RESET PUSHBUTTONS
00077 F05A 32 PUL A
00078 F05B BA A1F8 ORA A ASAVE COMBINE RESULTS FROM 2 READS
00079 F05E 81 60 CMP A #$60 BOTH BUTTONS PUSHED?
00080 F060 26 09 BNE PBM0 NO, SERVICE THE ONE BUTTON
00081 F062 B6 8104 LDA A TOGGL STORE VALUE OF TOGGLE
00082 F065 FE 8102 LDX HEXSW IN MEMORY
00083 F068 A7 00 STA A 0,X
00084 F06A 39 RTS
00085 F06B CE A1E0 PBM0 LDX #VCTR1
00086 F06E B6 A1F8 LDA A ASAVE GET BUTTON PUSHED
00087 F071 B7 8107 STA A PUSHB+1 SET PUSHBUTTON LIGHTS
00088 F074 44 PBM1 LSR A DETERMINE BUTTON PUSHED
00089 F075 25 04 BCS PBM2
00090 F077 08 INX
00091 F078 08 INX
00092 F079 20 F9 BRA PBM1
00093 F07B EE 00 PBM2 LDX 0,X LOAD VECTOR FOR JSR
00094 F07D AD 00 JSR 0,X DO BUTTON TASK
00095 F07F 7F 8107 CLR PUSHB+1 CLEAR PUSHBUTTON LIGHTS
00096 F082 39 RTS
00097
*
* INITIALIZE FRONT PANEL AND VECTORS
00098
* INALL
00099 F083 CE F003 LDX #VDRG+3 INITIALIZE 8 BUTTON VECTORS
00100 F086 FF A1E0 STX VCTR1 BUTTON1
00101 F089 CE F006 LDX #VDRG+6
00102 F08C FF A1E2 STX VCTR2 BUTTON2
00103 F08F CE F009 LDX #VDRG+9
00104 F092 FF A1E4 STX VCTR3 BUTTON3
00105 F095 CE F00C LDX #VDRG+$C
00106 F098 FF A1E6 STX VCTR4 BUTTON4
00107 F09B CE F00F LDX #VDRG+$F
00108 F09E FF A1E8 STX VCTR5 BUTTON5
00109 F0A1 CE F012 LDX #VDRG+$12
00110 F0A4 FF A1EA STX VCTR6 BUTTON6
00111 F0A7 CE F015 LDX #VDRG+$15
00112 F0AA FF A1EC STX VCTR7 BUTTON7
00113 F0AD CE F126 LDX #JOB8
00114 F0B0 FF A1EE STX VCTR8 BUTTON8
00115 F0B3 CE F034 LDX #SUB1 INITIALIZE LOOP ADDITIONS
00116 F0B6 FF A1F0 STX VSUB1

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PAGE 003  PBMON
00117 F0B9 CE F116      LDX  #NDSUB  DEFAULT TO RTS
00118 F0BC FF A1F2      STX  VSUB2
00119 F0BF CE 0000      LDX  #0000  INITIALIZE FRONT PANEL
00120 F0C2 FF 8108      STX  HEXLT+8
00121 F0C5 FF 810A      STX  HEXSM+8
00122 F0C8 FF 810C      STX  TOGGL+8
00123 F0CB FF 810E      STX  PUSHB+8
00124 F0CE FF 8102      STX  HEXSM  LOAD DATA DIRECTION REG.
00125 F0D1 CE FFFF      LDX  #FFFF
00126 F0D4 FF 8100      STX  HEXLT
00127 F0D7 CE 00FF      LDX  #00FF
00128 F0DA FF 8104      STX  TOGGL
00129 F0DD FF 8106      STX  PUSHB
00130 F0E0 CE 0404      LDX  #0404  LOAD CONTROL REGISTERS
00131 F0E3 FF 8108      STX  HEXLT+8
00132 F0E6 FF 810A      STX  HEXSM+8
00133 F0E9 FF 810C      STX  TOGGL+8
00134 F0EC CE 3C3C      LDX  #3C3C  DETERMINE PUSHBUTTON MODE
00135 F0EF FF 810E      STX  PUSHB+8  BRING CA2+CB2 HIGH
00136 F0F2 86 FF      LDA  A  #FF  *
00137 F0F4 B7 8107      STA  A  PUSHB+1  SET-RESET MODE
00138 F0F7 CE 3C34      LDX  #3C34  *
00139 F0FA FF 810E      STX  PUSHB+8  LATCH IN S-R
00140 F0FD 86 00      LDA  A  #00
00141 F0FF B7 8107      STA  A  PUSHB+1  TURN OFF PB LIGHTS
00142 F102 86 04      LDA  A  #04
00143 F104 B7 A1F5      STA  A  RXSAVE+1  SET UP BLINKING INTERVAL
00144 F107 86 C0      LDA  A  #C0
00145 F109 B7 8105      STA  A  TOGGL+1  SET FLASHING LIGHTS
00146 F10C 86 34      LDA  A  #34  RESET PUSHBUTTONS
00147 F10E B7 810E      STA  A  PUSHB+8
00148 F111 86 3C      LDA  A  #3C
00149 F113 B7 810E      STA  A  PUSHB+8
00150 F116 39          NDSUB  RTS
00151 *
00152 *  WINK-DELAYS FOR 200 MILLISECONDS
00153 F117 CE 00C8      WINK  LDX  #200
00154 F11A 7E F16F      JMP  DMILLI
00155 *
00156 *  PEEK-DISPLAY CONTENTS OF ADDRESS
00157 *  CONTAINED IN HEX SWITCH IN HEX LED.
00158 F11D FE 8102      PEEK  LDX  HEXSM
00159 F120 EE 00      LDX  0,X
00160 F122 FF 8100      STX  HEXLT
00161 F125 39          RTS
00162 *
00163 *  ASSIGN NEW VECTOR TO PUSHBUTTONS
00164 F126 CE A1E0      JOB8  LDX  #VCTR1  TTY MONITOR OR PB SETUP
00165 F129 B6 8104      LDA  A  TOGGL
00166 F12C 84 FE      AND  A  #SFE  NULL LAST BIT
00167 F12E 2B 05      JSXX  BMI  JSXY
00168 F130 08          INX
00169 F131 08          INX
00170 F132 48          ASL  A
00171 F133 20 F9      BRA  JSXX
00172 F135 B6 8102      JSXY  LDA  A  HEXSM  SETUP PB VECTOR ADDRESS
00173 F138 A7 00      STA  A  0,X
00174 F13A B6 8103      LDA  A  HEXSM+1

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PAGE 004  PBDON
00175 F13D A7 01      STA A  1,X
00176 F13F 8D D6      BSR  WINK      SLIGHT DELAY FOR PB LIGHT
00177 F141 39          RTS
00178
00179
00180 F142 7A A1F4 RSX  DISPLAY FLASHING LIGHTS
00181 F145 26 13      DEC  RXSAVE  WAIT TO MOVE
00182 F147 7A A1F5      BNE  RS1
00183 F14A 26 9E      DEC  RXSAVE+1
00184 F14C 86 8105      BNE  RS1
00185 F14F 16          LDA A  TOGGL+1  MOVE LITES
00186 F150 54          TAB
00187 F151 46          LSR B
00188 F152 B7 8105      ROR A
00189 F155 86 04      STA A  TOGGL+1
00190 F157 B7 A1F5      LDA A  #$04
00191 F15A 39          STA A  RXSAVE+1
00192
00193
00194
00195
00196 F15B FF A1F6 DMICRO STX  DTIME  DELAY (X) MICROSECONDS
00197 F15E B6 A1F6      LDA A  DTIME
00198 F161 F6 A1F7      LDA B  DTIME+1
00199 F164 C0 1F      SUB B  #31  MINIMUM DELAY
00200 F166 20 02      BRA  DMIXXY
00201 F168 C0 08      DMIXXX SUB B  #8  8 MICROSEC LOOP
00202 F16A 82 00      DMIXXY SBC A  #0
00203 F16C 2C FA      BGE  DMIXXX
00204 F16E 39          RTS  RETURN
00205
00206 F16F 86 03      DMILLI LDA A  #$03  DELAY (X) MILLISEC
00207 F171 C6 D2      LDA B  #$D2  1000 MICROSECOND DELAY LOOP
00208 F173 C0 08      DMILLI SUB B  #8
00209 F175 82 00      SBC A  #0
00210 F177 2A FA      BPL  DMILLI
00211 F179 01          NOP
00212 F17A 01          NOP
00213 F17B 09          DEX  COUNT MILLISECONDS
00214 F17C 26 F1      BNE  DMILLI
00215 F17E 39          RTS  RETURN
00216
END

```

TOTAL ERRORS 00000

!

APPENDIX D

KBTMON AND LISTING

I. GENERAL

The keyboard terminal monitor (KBTMON) program is written in MC6800 microprocessor assembly language for use with any American Standard Code for Information Interchange

(ASCII)—encoded KBT. The DUMP and LOAD functions are written for Texas Instruments (TI) 733 or ASR33 with automatic tape-control options. The program resides at locations \$FC00 through \$FFFF (a \$ indicates a hex No.) in read only memory (ROM) and uses RAM (random access memory)

\$A100 through \$A1FF locations for temporary storage and for the MPU stack. The ACIA board must be in slot 5.

KBTMON is entered by a restart or jump to the START vector at \$FC00. At entry, KBTMON responds with a carriage return, line feed, and asterisk (*); then it goes to the KBTMON control routine, which continuously monitors the ACIA receive data register for input from the KBT. When a valid input is received, the control routines branch to a task specified by the input character. These characters are valid inputs.

M—MEMORY—examines and/or changes memory location.

G—GO—transfers control to another routine.

D—DUMP—dumps memory onto KBT or TI output.

L—LOAD—loads tape.

P—PUNCH—punches memory onto punch paper tape or cassette.

C—COMPAR—compares two regions in memory.

Z—ZEROM—sets memory locations to zero.

X—MOVEM—moves memory.

Inputting one of these letters executes a subroutine. (The name of the subroutine follows the letter above.) Control is returned to the KBTMON control entry point after successful execution of a routine.

II. MAIN SUBROUTINES

The following is a description of each subroutine with instructions for executing that routine. Each subroutine can be used by other programs. Programs that use the L or M options must do a stack save, or STS \$A195, and a save of the address to which control is returned if an input error is encountered. This address should be stored with its high-order byte in \$A19C and low-order byte in \$A19D. The default address is that of KBTMON control.

A. MEMORY—M

A memory location can be examined and/or changed by typing M and the four hex digits representing the address (ADDR).

To execute MEMORY,

(1) Type M

(2) System responds with a space. Type the 4-digit hex address.

(3) System responds with a carriage return and line feed, prints ADDR and its contents, and waits.

(4) (a) To examine the next memory location, type carriage return. System will respond as in step (3) at the next memory location, ADDR+1.

(b) To change the memory, type the hex characters. (Invalid characters cause the system to respond as in step (3) at ADDR+1.)

(c) To return to KBTMON control, type any nonhex character except a carriage return.

B. GO—G

GO transfers control to another program or subroutine. The program counter is loaded with the address in locations \$A190—\$A191 (XBRNH). Control is returned to KBTMON when an unpaired RTS is encountered.

To execute GO,

(1) Type G

(2) System prints ADDR ? where ADDR is the address to which control will be transferred.

(3) Do one of the following.

(a) To transfer to address specified by step (2), type carriage return.

(b) To change the transfer address, enter a new transfer address.

(c) To exit before any transfer occurs, type any nonhex character except a carriage return.

C. DUMP—D

Specified memory contents are dumped on the keyboard in even blocks with the line format (beginning address followed by 16₁₀ bytes of memory).

To execute DUMP,

(1) Type D

(2) System prints ADDR1 ADDR2 ? where ADDR1 is the beginning memory address and ADDR2 is the ending address of the segment to be dumped.

(3) Do one of the following.

(a) To dump memory specified by step (2), type carriage return.

- (b) To specify a new memory segment, type a new beginning address.
System responds with ?
Type a new ending address.
- (c) To exit the DUMP mode before any action is taken, type any nonhex character except a carriage return.
- (4) To abort the routine while memory is being dumped, type S to return control to the loop and wait for a character to be input.

D. LOAD—L

The contents of a cassette or paper tape are loaded into memory at either the address on the tape or an address specified from the keyboard. A checksum is calculated and compared to the one on the tape. If a checksum discrepancy occurs, ? is printed, the tape is turned off, and control returns to KBTMON.

To execute LOAD,

- (1) Position the tape at the beginning of the information to be loaded. If using a TI terminal, turn on the automatic, or remote, device control (ADC).
- (2) Type L
- (3) System responds with ?
- (4) Do either (a) or (b).
 - (a) To load the tape into memory at the address that is on tape, hit the carriage return.
 - (b) To load the tape into memory at an address other than that on tape, enter the address that is on the tape.
System responds with ?
Enter the new address.

E. PUNCH—P

The contents of the memory between specified addresses are dumped on cassette or punch paper tape in Motorola's standard format shown in Fig. D-1.

To execute PUNCH,

- (1) Turn ADC on if at TI terminal.
- (2) Type P
- (3) System prints memory ADDR1 ADDR2 ? where ADDR1 is the beginning memory ad-

dress and ADDR2 is the ending memory address of the segment to be punched.

- (4) Do one of the following.
 - (a) To punch the memory specified by step (3), hit carriage return.
 - (b) To specify a new segment of memory, type a new beginning address.
System responds with ?
Type a new ending address.
 - (c) To exit the punch mode before any action is taken, type any nonhex character except a carriage return.
- (5) To abort the process while memory is being punched, type S. KBTMON returns to the control loop and waits for a character to be input.

F. COMPAR—C

Memory segment A is compared with memory segment B. Any differences are signaled by an error message of the form M ERR ADDR XX YY, where ADDR is the memory B address, XX is the memory B contents, and YY is the memory A contents.

To execute COMPAR,

- (1) Type C
- (2) System responds with ADDR1 ADDR2 ADDR3 ? where ADDR1 is the beginning memory A address, ADDR2 is the ending memory A address, and ADDR3 is the beginning memory B address.
- (3) Do one of the following.
 - (a) To compare memory specified by step (2), type carriage return.
 - (b) To specify new segments of memory, enter a new beginning memory A address.
System responds with ?
Enter a new ending memory A address.
System responds with ?
Enter a new beginning memory B address.
 - (c) To exit the compare mode before any action is taken, type any nonhex character except a carriage return.
- (4) To abort the process while compare errors are being printed, type S to return control to the loop and wait for a character to be input.

FRAMES 3 THROUGH N ARE HEXADECIMAL DIGITS (IN 7-BIT ASCII) WHICH ARE CONVERTED TO BCD. TWO BCD DIGITS ARE COMBINED TO MAKE ONE 8-BIT BYTE.

THE CHECKSUM IS THE ONE'S COMPLEMENT OF THE SUMMATION OF 8-BIT BYTES.

FRAME	CC = 30 HEADER RECORD	CC = 31 DATA RECORD	CC = 39 END OF FILE RECORD
1. START OF RECORD	53	53	53
2. TYPE OF RECORD	30	31	39
3. BYTE COUNT	31	31	30
4.	32	35	33
5.	30	31	30
6. ADDRESS/SIZE	30	31	30
7.	30	30	30
8.	30	30	30
9.	34	39	48
10. DATA	38	38	43
.	34	30	
.	34	32	
.	36		
.	32	41	
.		48	
N CHECKSUM	39	AB (CHECKSUM)	FC (CHECKSUM)
	45		

Fig. D-1.

Motorola standard tape format. (This figure is reproduced by permission from Motorola Engineering Note 100.)

G. ZEROM—Z

All specified memory locations are set to zero.

To execute ZEROM,

(1) Type Z

(2) System responds with ADDR1 ADDR2 ?
where ADDR1 is the beginning memory address to zero and ADDR2 is the ending memory address to zero.

(3) Do one of the following.

(a) To set the memory specified in step (2) to zero, type carriage return.

(b) To specify a new memory to be set to zero, type a new beginning memory address to zero.

System responds with ?

Type a new ending memory address to zero.

(c) To exit the zero mode before any action is taken, type any nonhex character except a carriage return.

H. MOVEM—X

Memory contents are moved from one location in memory to another specified location. The contents of the newly filled memory are compared to the original memory; any unsuccessful move is signaled by an error message of the form M ERR ADDR XX YY, where M is the memory, ADDR is the address at which the error occurs, XX is the incorrect memory contents, and YY is the original memory contents.

To execute MOVEM,

(1) Type X

(2) System responds with ADDR1 ADDR2 ADDR3 ? where ADDR1 is the beginning memory address to transfer, ADDR2 is the ending memory address to transfer, and ADDR3 is the beginning memory address to which the move is made.

(3) Do one of the following.

(a) To make the transfer specified by step (2), type carriage return.

(b) To specify a new transfer, type a new beginning transfer memory address.

System responds with ?

Type a new ending transfer memory address.

System responds with ?

Type a new beginning address to which to transfer.

(c) To exit the transfer mode before any action is taken, type any nonhex character except a carriage return.

(4) To abort the process while compare errors are being printed, type S to return control to the loop and wait for a character to be input.

III. I/O ROUTINES

The following I/O routines are available for use in applications programs. They are used by JSR \$XX-XX instruction where \$XXXXX is the hex address of the routine given after the routine name.

A. Input Routines

1. **INCH \$FC2A.** One 8-bit word is loaded from the ACIA input register into the A accumulator. The character is echoed on the terminal.

2. **INHEX \$FC03.** An 8-bit word is loaded into the A accumulator from the ACIA input register. The character is echoed and checked whether it is a valid hex character, 0-9, A-F. A nonhex character causes a return to the specified address.*

3. **BYTE \$FC24.** Two valid hex characters are loaded. They are converted to their 4-bit binary representation and then packed in the A register. If either of the input characters is not a valid hex character, a return to the specified address is executed.*

4. **BADDR \$FC06.** Four characters are loaded from the ACIA. The hex characters are converted to their binary representation and packed in the X register. The high-order address byte is also stored in \$A18A; the low-order address byte is stored in \$A18B. The address is echoed. An encounter of a nonhex character causes program control to return to the specified address.*

B. Output Routines

1. **OUTCH \$FC09.** One ASCII character is output. The routine is called with the character to be output in the A register.

2. **OUT2H \$FC0C.** Two hexadecimal characters are output. The routine is called with the memory address of the location that contains the packed hex characters in the X register.

*Control is returned to the address specified in locations \$A19C and \$A19D. KBTMON defaults the return to KBTMON control on entry into KBTMON from a restart.

3. **OUTS \$FC15.** A space is output.

4. **OUT2HS \$FC12.** OUT2H and OUTS are combined.

5. **OUT4HS \$FC0F.** Four hex characters followed by a space are output. The characters to be output are packed in two sequential memory locations; the address of the first is entered in the X register before the call is made.

6. **PDATA1 \$FC18.** A data string is printed. The X register contains the beginning memory address of the sequential locations that contain the ASCII character representations to be output. Output is terminated when \$04 is encountered in a memory location.

7. **PDATA \$FC1B.** PDATA is the same as PDATA1 except a carriage return-line feed is output before the ASCII character string.

8. **PCRLF \$FC1E.** A carriage return and line feed are output.

IV. OTHER FEATURES

A. Stack

KBTMON can print the contents of the MPU stack. For example, it can dump the contents of the MPU registers at a particular point in the software. To execute this, load the secondary SWI vector at \$A1FA with \$FC21 and then insert an SWI instruction in the software where you want to know the contents of the MPU registers. The stack contents and the location of the stack pointer are printed on a single line in the order:

- condition code register,
- B accumulator,
- A accumulator,
- X register high-order byte,
- X register low-order byte,
- program counter high-order byte,
- program counter low-order byte, and
- stack pointer high- and low-order byte.

B. Interrupt Vectors

KBTMON creates secondary IRQ, NMI, and SWI vectors. (These interrupts are defined in the Motorola 6800 Applications and Programming manuals.) The address to which an SWI interrupt is to be transferred is entered in \$A1FA and \$A1FB; the vector for IRQ is entered at \$A1FC and \$A1FD, and the NMI vector is entered at \$A1FE and \$A1FF.

```

PAGE 001 KBTMON
00001
00002
00003
00004
00005
00006
00007
00008
00009
00010
00011
00012 8500 ACIACS EQU $8500 ACIA CONTROL/STATUS
00013 8501 ACIADA EQU $8501 ACIA DATA REGISTER
00014 F000 PBLOOP EQU $F000 PUSHBUTTON LOOP ENTRY
00015 F010 PBINT EQU PBLOOP+$18 INIT. PUSHBUTTONS
00016 A100 RAM EQU $A100
00017 A1FA VSWI EQU RAM+$FA SWI VECTOR
00018 A1FC VIRQ EQU RAM+$FC IRQ VECTOR
00019 A1FE VNMI EQU RAM+$FE NMI VECTOR
00020
00021 FC00 DRG $FC00
00022 OPT NOG
00023
00024 FC00 7E FC2D VENTR JMP CONTRL JUMP TO CONTRL
00025 FC03 7E FCA3 VINHEX JMP INHEX INPUT HEX CHARACTER
00026 FC06 7E FD9B VBADDR JMP BADDR INPUT ADDRESS
00027 FC09 7E FE23 VOTCH JMP OUTCH OUTPUT ONE CHARACTER
00028 FC0C 7E FE3C VOT2H JMP OUT2H OUTPUT TWO HEX CHARACTERS
00029 FC0F 7E FE46 VOT4HS JMP OUT4HS OUTPUT 4 CHARS. AND A SPACE
00030 FC12 7E FE48 VOT2HS JMP OUT2HS OUTPUT 2 CHARS. AND A SPACE
00031 FC15 7E FE4A VOTS JMP OUTS OUTPUT A SPACE
00032 FC18 7E FE5E VPDAT1 JMP PDATA1 PRINT DATA STRING
00033 FC1B 7E FE5C VPDATA JMP PDATA PRINT CR-LF, DATA STRING
00034 FC1E 7E FE69 VPCRLF JMP PCRLF PRINT CR-LF
00035 FC21 7E FE75 VPSTK JMP PSTK PRINT STACK
00036 FC24 7E FDB3 VBYTE JMP BYTE INPUT ONE BYTE (< 7 BITS)
00037 FC27 7E FC95 VBINH JMP INCH4 DEFAULT TO RTS
00038 FC2A 7E FC76 VINCH JMP INCH INPUT ONE ASCII CHARACTER
00039
00040
00041
00042
00043
00044 CONTROL
00045 FC2D 7F A199 CONTRL CLR NOECD DON'T ECHO CHARACTER
00046 FC30 BF A195 STS STSAVE SAVE FOR RECOVERY
00047 FC33 CE FC2D LDX #CONTRL
00048 FC36 FF A19C STX ADRET STORE FOR RECOVERY
00049 FC39 BD FE69 JSR PCRLF CR-LF
00050 FC3C 86 2A LDA A #$2A OUTPUT ASTERISK
00051 FC3E BD FE23 JSR OUTCH
00052 FC41 8D 33 BSR INCH WAIT FOR CHARACTER
00053 FC43 16 TAB
00054 FC44 BD FE4A JSR OUTS OUTPUT SPACE
00055
00056 FC47 CE FC5E LDX #TABL DETERMINE WHICH CHAR.
00057 FC4A E1 00 LOOK CMP B 0,X
00058 FC4C 27 0A BEQ LOOK1 GO TO ROUTINE

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PAGE 002 KBTMON
00059 FC4E 08 INX
00060 FC4F 08 INX
00061 FC50 08 INX MOVE TO NEXT IN TABLE
00062 FC51 8C FC76 CPX #TABEND
00063 FC54 26 F4 BNE LOOK KEEP LOOKING
00064 FC56 20 D5 BRA CONTRL NOT VALID CHARACTER
00065 FC58 EE 01 LOOK1 LDX 1,X GET ADDRESS OF ROUTINE
00066 FC5A AD 00 JSR 0,X TAKE ACTION
00067 FC5C 20 CF BRA CONTRL
00068
00069 FC5E 4C * TABL FCC /L/
00070 FC5F FCC0 FDB LOAD LOAD MEMORY FROM TAPE
00071 FC61 4D FCC /M/
00072 FC62 FDE3 FDB CHANGE CHANGE MEMORY LOCATION
00073 FC64 5A FCC /Z/
00074 FC65 FF4C FDB ZEROM ZERO MEMORY
00075 FC67 58 FCC /X/
00076 FC68 FF1F FDB MOVEM MOVE MEMORY
00077 FC6A 43 FCC /C/
00078 FC6B FF5E FDB COMPAR COMPARE MEMORY
00079 FC6D 50 FCC /P/
00080 FC6E FE88 FDB PUNCH PUNCH MEMORY TO TAPE
00081 FC70 44 FCC /D/
00082 FC71 FEF2 FDB DUMP DUMP MEMORY TO TERMINAL
00083 FC73 47 FCC /G/
00084 FC74 FDC9 FDB GO JSR TO SUBROUTINE
00085 FC76 TABEND EQU *
00086
00087 *
00088 * INPUT ONE CHARACTER INTO A ACCUMULATOR
00089 * STRIP PARITY
00090
00091 FC76 BD FE07 INCH EQU *
00092 FC79 7D A19F INCH1 JSR PBLOOK LOOK AT PB LOOP
00093 FC7C 26 16 TST NOACIA ACIA IN SLOT 5?
00094 FC7E B6 8500 LDA A ACIACS NO, RETURN
00095 FC81 85 01 BIT A #$01 CHARACTER HERE YET?
00096 FC83 27 F1 BEQ INCH CHECK STATUS
00097 FC85 84 70 AND A #$70 WAIT FOR CHAR.
00098 FC87 27 0D BEQ INCH2 TRANSMISSION ERRORS
00099 FC89 BD FE15 JSR DUTHL NO ERRORS
00100 FC8C 86 45 LDA A #E OUTPUT ERROR NUMBER
00101 FC8E BD FE23 JSR DUTCH OUTPUT E FOR ERROR
00102 FC91 B6 8501 LDA A ACIADA READ BAD CHARACTER
00103 FC94 4F INCH3 CLR A ABORT
00104 FC95 39 INCH4 RTS
00105 FC96 B6 8501 INCH2 LDA A ACIADA READ CHARACTER
00106 FC99 84 7F AND A #$7F STRIP PARITY
00107 *
00108 * CMPA #$7F RUBOUT?
00109 FC9B 7D A199 BEQ INCH READ ANOTHER CHARACTER
00110 FC9E 26 F5 TST NOECQ ECHO CHARACTER?
00111 FCA0 7E FE23 BNE INCH4
00112 JMP DUTCH OUTPUT CHARACTER
00113
00114 *
00115 * INHEX CHECKS IF INPUT CHARACTER
00116 * WAS HEX

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PAGE 003 KBTMDN

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00117      *
00118      *
00119      *
00120      *
00121 FCA7 8D D1 INHX BSR INCH
00122 FCA7 81 30 INHX1 CMP A #$30
00123 FCA7 2B 0F BMI C1 NOT HEX
00124 FCA9 81 39 CMP A #$39
00125 FCAB 2F 0A BLE IN1HG
00126 FCAD 81 41 CMP A #$41
00127 FCAF 2B 07 BMI C1 NOT HEX
00128 FCB1 81 46 CMP A #$46
00129 FCB3 2E 03 BGT C1 NOT HEX
00130 FCB5 80 07 SUB A #7
00131 FCB7 39 IN1HG RTS
00132 FCB8 8E A195 C1 LDS STSAVE NOT A HEX CHARACTER
00133 FCBB FE A19C LDX ADRET RECOVER
00134 FCBE 6E 00 JMP 0X

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PAGE 004 KBTMON

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00136 .....
00137 *
00138 *      LOAD
00139 *
00140 *      TYPE L
00141 *
00142 *      LOAD TURNS READER ON.
00143 *      AFTER S1 ENCOUNTERED LOADS TAPE
00144 *      INTO MEMORY AT ADDRESS ON TAPE.
00145 *      CALCULATES AND CHECKS CHECKSUM.
00146 *      TURNS READER OFF WHEN S9 READ.
00147 *
00148 FCC0 7F A19B LOAD CLR CHNGF CLEAR ADDR CHANGE FLAG
00149 FCC3 86 02 LDA A #2 GET ADDRESSES
00150 FCC5 B7 A1AD STA A ADDNM1
00151 FCC8 BD FD56 JSR GET
00152 FCCB 25 15 BCS LOAD2 NO OFFSET
00153 FCCD B6 A18D LDA B XSAVE+1
00154 FCD0 F6 A18C LDA B XSAVE RAM ADDRESS IN ACC A+B
00155 FCD3 B0 A18F SUB A XSAVE+1
00156 FCD6 F2 A18E SBC B XSAVE1 SUBTRACT TAPE ADDRESS
00157 FCD9 B7 A18D STA A XSAVE+1 STORE DIFF. IN XSAVE
00158 FCD0 F7 A18C STA B XSAVE
00159 FCD0 F7 A18C INC CHNGF NEW ADDRESS
00160 FCE2 0F LOAD2 SEI SET INTERRUPT MASK
00161 FCE3 7C A199 INC NDECO SET NO ECHO FLAG
00162 FCE6 86 11 LDA A #11 TURN READER ON WITH
00163 FCE8 BD FE23 JSR DUTCH ASCII CONTROL CHARACTER
00164 FCEB 8D 89 LOAD3 BSR INCH LOOK FOR ASCII
00165 FCEB 81 53 CMP A #'S S CHARACTER
00166 FCEF 26 FA BNE LOAD3 1ST CHAR NOT (<S)
00167 FCF1 7F A188 CLR CKSM0 ACC. CKCKM DURING BYTE
00168 FCF4 BD FC76 JSR INCH READ CHAR
00169 FCF7 81 39 CMP A #'9 END OF LOAD?
00170 FCF9 27 44 BEQ LOAD21 YES
00171 FCFB 81 31 CMP A #'1
00172 FCFD 26 EC BNE LOAD3 2ND CHAR NOT (<1)
00173 FCFF BD FDB3 JSR BYTE READ BYTE
00174 FD02 80 02 SUB A #2 SUB. BYTES FOR ADDRESS
00175 FD04 B7 A189 STA A BYTECT BYTE COUNT
00176 * BUILD ADDRESS
00177 FD07 BD FD9B JSR BADDR ADDR. IN X-REG
00178 FD0A 7D A19B TST CHNGF ADDRESS CHANGE?
00179 FD0D 27 18 BEQ LOAD11 NO
00180 FD0F FF A18E STX XSAVE1 TAPE ADDRESS IN XSAVE1
00181 FD12 B6 A18F LDA A XSAVE1+1 DIFF. IN XSAVE1
00182 FD15 F6 A18E LDA B XSAVE1
00183 FD18 B0 A18D SUB A XSAVE+1 SUBTRACT OFFSET
00184 FD1B F2 A18C SBC B XSAVE
00185 FD1E B7 A18F STA A XSAVE+1 PROPER ADDRESS
00186 FD21 F7 A18E STA B XSAVE1
00187 FD24 FE A18E LDX XSAVE1
00188 * STORE DATA
00189 FD27 BD FDB3 LOAD11 JSR BYTE BYTE IN A-REG
00190 FD2A 7A A189 DEC BYTECT DEC BYTE COUNT
00191 FD2D 27 08 BEQ LOAD15 DONE
00192 FD2F F7 A194 STA B CKSM
00193 FD32 A7 00 STA A 0+X STORE DATA

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PAGE 005 KBTMDN
00194 FD34 08 LOAD14 INX
00195 FD35 20 F0 BRA LOAD11 CHECK CHECKSUMS
00196 FD37 43 LOAD15 COM A COMPLEMENT BYTE SUM
00197 FD38 B1 A194 CMP A CKSM COMPARE WITH INPUT CHECKSUM
00198 FD3B 27 AE BEQ LOAD3 YES
00199 FD3D 8D 6A LOAD19 BSR DUTQ OUTPUT ?
00200 FD3F 86 13 LOAD21 LDA A $S13 TURN READER OFF
00201 FD41 BD FE23 JSR DUTCH WITH ASCII CHARACTER
00202 FD44 0E CLI CLEAR INTERRUPT MASK
00203 FD45 7F A199 CLR NDECO CLEAR NO ECHO FLAG
00204 FD48 39 RTS
00205
00206
00207
00208 FD49 PRADD EQU PRINT ADDRESSES
00209 FD49 16 TAB
00210 FD4A B7 A1AD STA A ADDNM1 SAVE # OF ADDRESSES
00211 FD4D CE A1A0 LDX #STRTO
00212 FD50 BD FE46 PRADD1 JSR OUT4HS OUTPUT ADDRESS
00213 FD53 5A DEC B ALL PRINTED?
00214 FD54 26 FA BNE PRADD1
00215 FD56 8D 51 GET BSR DUTQ OUTPUT ?
00216 FD58 BD FC76 JSR INCH CHANGE ADDRESSES
00217 FD5B 81 0D CMP A $S9D CARRIAGE RETURN?
00218 FD5D 26 17 BNE GETADD GET NEW ADDRESSES
00219 FD5F BD FE69 JSR PCRLF EXECUTION STARTED
00220 FD62 0D SEC SIGNALS NO NEW ADDRESS
00221 FD63 FE A1A0 GET1 LDX STRTO RESET ADDRESS VECTORS
00222 FD66 FF A18C STX XSAVE
00223 FD69 FE A1A2 LDX STOP0
00224 FD6C FF A18E STX XSAVE1
00225 FD6F FE A1A4 LDX STRT1
00226 FD72 FF A1AA STX XSAVE2
00227 FD75 39 RTS
00228 FD76 8D 1D GETADD BSR BADDR2 GET 1ST NEW ADDRESS
00229 FD78 FF A1A0 STX STRTO SAVE IT
00230 FD7B 7A A1AD DEC ADDNM1 NUMBER OF ADDRESSES TO GET
00231 FD7E 27 0F BEQ GETEND DONE
00232 FD80 8D 17 BSR BADDR1 GET 2ND NEW ADDRESS
00233 FD82 FF A1A2 STX STOP0 SAVE IT
00234 FD85 7A A1AD DEC ADDNM1 # OF ADDRESSES TO GET YET
00235 FD88 27 05 BEQ GETEND DONE
00236 FD8A 8D 0D BSR BADDR1 GET 3RD NEW ADDRESS
00237 FD8C FF A1A4 STX STRT1 SAVEIT
00238 FD8F BD FE69 GETEND JSR PCRLF SIGNALS EXECUTION STARTED
00239 FD92 0C CLC SIGNALS NEW ADDRESSES ENTERED
00240 FD93 20 CE BRA GET1
00241
00242
00243 FD95 8D 17 BUILD ADDRESS
00244 FD97 20 04 BADDR2 BSR BYTE2 CONTINUE PROCESSING CHAR
00245 FD99 8D 0E BADDR1 BSR DUTQ OUTPUT ?
00246 FD9B 8D 16 BADDR BSR BYTE READ 2 HEX CHAR.
00247 FD9D B7 A18A BADDR3 STA A XHI
00248 FDA0 8D 11 BSR BYTE READ 2 HEX CHAR.
00249 FDA2 B7 A18B STA A XLOW
00250 FDA5 FE A19A LDX XHI
00251 FDA8 39 RTS

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PAGE 006 KBTMON
00252
00253 FDB9 86 3F OUTQ LDA A #1? OUTPUT QUESTION MARK
00254 FDBB 8D 76 BSR OUTCH
00255 FDBD 39 RTS
00256
00257
00258 INPUT BYTE
00259 BEFORE BRANCHING TO BYTE OR INHEX
00260 STORE STACK POINTER AT STSAVE AND
00261 SET ADRET.
00262 FDBE 8D FCA5 BYTE2 JSR INHX1 FINISH CHAR ALREADY IN A
00263 FDB1 20 03 BRA BYTE1
00264 FDB3 8D FCA3 BYTE JSR INHEX GET LEFT DIGIT
00265 FDB6 48 BYTE1 ASL A PACK IT
00266 FDB7 48 ASL A
00267 FDB8 48 ASL A
00268 FDB9 48 ASL A
00269 FDBA 16 TAB
00270 FDBB 8D FCA3 JSR INHEX GET RIGHT DIGIT
00271 FDBE 84 0F AND A #$0F MASK TO 4 BITS
00272 FDC0 1B ABA MERGE
00273 FDC1 16 TAB 1ST TIME BYTE CT IN A-ACC
00274 FDC2 FB A188 ADD B CKSM0 ACCUMULATE CHECKSUM
00275 FDC5 F7 A188 STA B CKSM0
00276 FDC8 39 RTS
00277
00278
00279
00280
00281 TRANSFERS PROGRAM CONTROL
00282 FDC9 CE A190 GO LDX #XBRNH OUTPUT CURRENT GO ADDRESS
00283 FDCC 8D FE46 JSR OUT4HS
00284 FDCF 8D D8 BSR OUTQ OUTPUT ?
00285 FDD1 8D FC76 JSR INCH
00286 FDD4 81 0D CMP A #$0D NEW VECTOR?
00287 FDD6 27 05 BEQ GO1 NO
00288 FDD8 8D BB BSR BADDR2 GET NEW GO ADDRESS
00289 FDDA FF A190 STX XBRNH SAVE IT
00290 FDDD FE A190 GO1 LDX XBRNH GET ADDRESS
00291 FDE0 AD 00 JSR 0-X GO TO ROUTINE
00292 FDE2 39 RTS
00293

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PAGE 007 KBTMON
00295 *****
00296
00297 CHANGE MEMORY LOCATION
00298
00299 TYPE M
00300
00301 EXAMINE MEMORY LOCATION BY TYPING
00302 M AND LOCATION.
00303 CHANGE VALUE IN LOCATION BY
00304 TYPING SPACE AND NEW VALUE AFTER
00305 OLD VALUE.
00306 EXIT BY TYPING SPACE, THEN RETURN.
00307
00308 CHANGE MEMORY (M AAAA DD NN)
00309 WHERE AAAA = ADDRESS
00310 DD = OLD DATA
00311 NN = NEW DATA
00312
00313 FDE3 8D B6 CHANGE BSR BADDR BUILD ADDRESS
00314 FDE5 BD FE69 RET1 JSR PCRLF OUTPUT CR-LF
00315 FDE8 CE A18A LDX #XHI
00316 FDEB 8D 59 BSR OUT4HS PRINT ADDRESS
00317 FDED FE A18A LDX XHI
00318 FDF0 8D 56 BSR OUT2HS PRINT PRESENT DATA
00319 FDF2 FF A18A STX XHI STORE NEXT LOCATION ADDRESS
00320 FDF5 BD FC76 JSR INCH INPUT 1 CHARACTER
00321 FDF8 81 0D CMP A #$0D LOOK FOR CR CODE
00322 FDFA 27 E9 BEQ RET1 GO TO NEXT LOCATION
00323 FDFC 8D B0 BSR BYTE2 INPUT NEW DATA
00324 FDFF 09 DEX
00325 FDFF A7 00 STA A 0,X PUT NEW DATA IN MEMORY
00326 FE01 A1 00 CMP A 0,X VERIFY DATA
00327 FE03 27 E0 BEQ RET1 SUCCESSFUL CHANGE
00328 FE05 20 A2 BRA OUT0 UNSUCCESSFUL CHANGE
00329
00330
00331 FE07 PBLOK EQU * MONITOR PUSHBUTTONS
00332 FE07 36 PSH A SAVE REGISTERS
00333 FE08 37 PSH B
00334 FE09 FF A1A8 STX OUTX
00335 FE0C BD F000 JSR PBLOP LOOK AT BUTTONS
00336 FE0F FE A1A8 LDX OUTX RESTORE REGISTERS
00337 FE12 33 PUL B
00338 FE13 32 PUL A
00339 FE14 39 RTS
00340
00341
00342 FE15 44 DUTHL LSR A OUT HEX LEFT DIGIT
00343 FE16 44 LSR A
00344 FE17 44 LSR A
00345 FE18 44 LSR A
00346 FE19 84 0F DUTHR AND A #$F OUT HEX RIGHT DIGIT
00347 FE1B 8B 30 ADD A #$30
00348 FE1D 81 39 CMP A #$39
00349 FE1F 23 02 BLS DUTHC
00350 FE21 8B 07 ADD A #$7
00351
00352 OUTPUT ONE CHARACTER

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PAGE 008 KBTMDN
00353 FE23 DUTCH EQU *
00354 FE23 37 PSH B SAVE B
00355 FE24 8D E1 DUTC1 BSR PBL00K LOOK AT PB LOOP
00356 FE26 7D A19F TST N0ACIA ACIA IN SLOT 5?
00357 FE29 26 0E BNE DUTC5 NO
00358 FE2B F6 8500 LDA B ACIACS CHECK REGISTER
00359 FE2E 57 ASR B
00360 FE2F 57 ASR B
00361 FE30 24 F2 BCC DUTC1 XMIT NOT READY
00362 FE32 87 8501 STA A ACIADA OUTPUT CHARACTER
00363 FE35 81 0D CMP A #$0D
00364 FE37 27 15 BEQ NULLS DELAY WITH NULLS
00365 FE39 33 DUTC5 PUL B RESTORE B-REG
00366 FE3A 0C CLC CARRY CLEAR ON RETURN
00367 FE3B 39 RTS
00368 *
00369 *
00370 FE3C A6 00 DUT2H LDA A 0*X OUTPUT 2 HEX CHAR
00371 FE3E 8D D5 BSR DUTHL OUT LEFT HEX CHAR
00372 FE40 A6 00 LDA A 0*X
00373 FE42 8D D5 BSR DUTHR OUT RIGHT HEX CHAR
00374 FE44 08 INX
00375 FE45 39 RTS
00376 *
00377 FE46 8D F4 DUT4HS BSR DUT2H OUTPUT MOST SIG BYTE
00378 FE48 8D F2 DUT2HS BSR DUT2H OUTPUT 2 HEX CHAR + SPACE
00379 FE4A 86 20 DUTS LDA A #$20 SPACE
00380 FE4C 20 D5 BRA DUTCH
00381 *
00382 FE4E C6 04 NULLS LDA B #$04 OUTPUT 4 NULLS
00383 FE50 36 PSH A SAVE A
00384 FE51 86 00 NULL1 LDA A #$00 NULL
00385 FE53 8D CE BSR DUTCH OUTPUT NULL
00386 FE55 5A DEC B ALL NULLS OUTPUT?
00387 FE56 26 F9 BNE NULL1
00388 FE58 32 PUL A
00389 FE59 33 PUL B RESTORE B
00390 FE5A 0C CLC CARRY CLEAR ON RETURN
00391 FE5B 39 RTS
00392 *
00393 *
00394 FE5C 8D 08 PDATA BSR PCRLF PRINT CR-LF, DATA STRING
00395 FE5E A6 00 PDATA1 LDA A 0*X PRINT DATA STRING
00396 FE60 81 04 CMP A #$04
00397 FE62 27 10 BEQ PDATA2 04 SIGNALS END OF STRING
00398 FE64 8D BD BSR DUTCH OUTPUT CHARACTER
00399 FE66 08 INX GO ON TO NEXT CHARACTER
00400 FE67 20 F5 BRA PDATA1
00401 *
00402 FE69 FF A197 PCRLF STX SAVEX PRINT CR-LF
00403 FE6C CE FF9F LDX #CRLF CR-LF STRING
00404 FE6F 8D ED BSR PDATA1 OUTPUT IT
00405 FE71 FE A197 LDX SAVEX
00406 FE74 39 PDATA2 RTS

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PAGE 009 KBTMON
00408 *****
00409 *
00410 * PRINT CONTENTS OF STACK
00411 *
00412 *
00413 * CALL FORMAT:
00414 * SET SWI POINTER (A1FA) TO PSTK,
00415 * EXECUTE SWI
00416 *
00417 * WILL PRINT CONTENTS OF STACK IN
00418 * THIS ORDER:
00419 * CC B A XH XL PH PL SPH SPL
00420 FE75 8D F2 PSTK BSR PCRLF
00421 FE77 BF A186 STS SP STORE STACK POINTER
00422 FE7A 30 TSX
00423 FE7B C6 07 LDA B #7
00424 FE7D 8D C9 PSTK2 BSR OUT2HS OUT 2 HEX, SPACE
00425 FE7F 5A DEC B
00426 FE80 26 FB BNE PSTK2
00427 FE82 CE A186 LDX #SP OUTPUT STACK POINTER
00428 FE85 8D BF BSR OUT4HS
00429 FE87 3B RTI
00430 *

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PAGE 010 KBTMON

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00432 .....
00433 *
00434 * PUNCH TO TAPE
00435 *
00436 * TYPE P
00437 *
00438 * TAPE RECORD TURNED ON.
00439 * DUMPS ON CASSETTE (PUNCH) MEMORY
00440 * CONTENTS BETWEEN BEGINNING AND
00441 * ENDING ADDRESS.
00442 * FORMAT OF DUMP:
00443 * S1 SIGNALS START OF DATA RECORD
00444 * 13 BYTE COUNT
00445 * ADDRESS IN NEXT TWO BYTES
00446 * DATA IN NEXT 16 BYTES
00447 * CHECKSUM IN NEXT BYTE
00448 * S9 SIGNALS END OF FILE RECORD
00449 * TAPE RECORD TURNED OFF.
00450 *
00451 PUNCH EQU *
00452 FE88 86 02 LDA A #2
00453 FE8A BD FD49 JSR PRADD GET ADDRESSES
00454 FE8D 86 12 LDA A #S12 TURN TTY PUNCH ON
00455 FE8F 8D 92 BSR DUTCH WITH ASCII CHARACTER
00456 FE91 B6 A1A3 PUN11 LDA A STOP0+1 DETERMINE NUMBER OF
00457 FE94 B0 A18D SUB A XSAVE+1 BYTES REMAINING
00458 FE97 F6 A1A2 LDA B STOP0
00459 FE9A F2 A18C SBC B XSAVE
00460 FE9D 26 04 BNE PUN22
00461 FE9F 81 10 CMP A #16 LESS THAN 16 BYTES ON RECORD
00462 FEA1 25 02 BCS PUN23 16(DEC.)>A
00463 FEA3 86 0F PUN22 LDA A #15
00464 FEA5 8B 04 PUN23 ADD A #4
00465 FEA7 B7 A192 STA A MCNT BYTE COUNT THIS RECORD
00466 FEA8 80 03 SUB A #3
00467 FEAC B7 A193 STA A TEMP DATA BYTE COUNT THIS RECORD
00468 FEAF CE FFA3 LDX #MTAPE1 PUNCH CR,LF, NULLS,S1
00469 FEB2 8D AA BSR PDATA1
00470 FEB4 5F CLR B ZERO CHECKSUM
00471 FEB5 CE A192 LDX #MCNT PUNCH FRAME COUNT
00472 FEB8 8D 33 BSR PUNT2 2 HEX CHARACTERS
00473 FEBA CE A18C LDX #XSAVE PUNCH ADDRESS
00474 FEBD 8D 2E BSR PUNT2 4 HEX CHARACTERS
00475 FEBF 8D 2C BSR PUNT2
00476 FEC1 FE A18C LDX XSAVE SET UP TO PUNCH DATA
00477 FEC4 8D 27 PUN32 BSR PUNT2 PUNCH ONE BYTE (2 FRAMES)
00478 FEC6 7A A193 DEC TEMP DECREMENT BYTE COUNT
00479 FEC9 26 F9 BNE PUN32 FINISHED RECORD?
00480 FECB FF A18C STX XSAVE YES
00481 *
00482 FECE 53 COM B GENERATE CHECKSUM
00483 FECF 37 PSH B
00484 FED0 30 TSX
00485 FED1 8D 1A BSR PUNT2 PUNCH CHECKSUM
00486 FED3 33 PUL B RESTORE STACK
00487 FED4 BD FF41 JSR SCHCK INPUT S ?
00488 FED7 FE A18C LDX XSAVE ALL DATA PUNCHED?
00489 FEDA 09 DEX

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PAGE 011 KBTMON
00490 FEDB BC A1A2 CPX STOP0
00491 FEDE 26 B1 BNE PUN11 NOT FINISHED
00492 FEE0 CE FFAF PUN33 LDX #MS9 OUTPUT S9
00493 FEE3 BD FE5E JSR PCATA1
00494 FEE6 36 PSH A
00495 FEE7 37 PSH B
00496 FEE8 C6 1D LDA B #29
00497 FEER 7E FE51 JMP NULL1 FILL BUFFER WITH NULLS
00498
00499 FEED EB 00 PUNT2 ADD B 0,X UPDATE CHECKSUM
00500 FEEF 7E FE3C JMP OUT2H PUNCH 2 HEX CHARACTERS

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PAGE 012 KBTMON
00502 *****
00503 *
00504 * DUMP MEMORY
00505 *
00506 * TYPE, D
00507 *
00508 * DUMPS MEMORY BETWEEN SPECIFIED
00509 * ADDRESSES IN BLOCKS OF 16 BYTES.
00510 *
00511 FEF2 DUMP EQU *
00512 FEF2 86 02 LDA A #2
00513 FEF4 BD FD49 JSR PRADD PRINT/GET ADDRESSES
00514 FEF7 B6 A18D LDA A XSAVE+1
00515 FEFA 84 F0 AND A #$F0 START AT EVEN ADDRESS
00516 FEFC B7 A18D STA A XSAVE+1
00517 FEFF BD FE69 DUMP2 JSR PCRLF OUTPUT CR-LF
00518 FF02 8D 3D BSR SCHCK
00519 FF04 C6 11 LDA B #17
00520 FF06 CE A18C LDX #XSAVE
00521 FF09 BD FE46 JSR OUT4HS OUTPUT ADDRESS AT LINE BEGIN
00522 FF0C 5A DUMP4 DEC B BYTES TO PRINT YET?
00523 FF0D 27 F0 BEQ DUMP2
00524 FF0F FE A18C LDX XSAVE
00525 FF12 BD FE48 JSR OUT2HS OUTPUT MEMORY BYTE
00526 FF15 FF A18C STX XSAVE
00527 FF18 09 DEX
00528 FF19 BC A1A2 CPX STOP0 ALL BYTES PRINTED
00529 FF1C 26 EE BNE DUMP4
00530 FF1E 39 RTS

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PAGE 013 KBTMON
00532 *****
00533 *
00534 * CORE MOVING PROGRAM
00535 *
00536 * TYPE X
00537 *
00538 * MOVES MEMORY CONTENTS LOCATED BETWEEN
00539 * SPECIFIED ADDRESSES TO NEW ADDRESS
00540 *
00541 FF1F MOVEM EQU *
00542 FF1F 86 03 LDA A #3
00543 FF21 8D FD49 JSR PRADD PRINT/GET ADDRESSES
00544 FF24 FE A18C TOP LDX XSAVE PTR TO OLD LOCATION
00545 FF27 09 DEX
00546 FF28 08 TOP1 INX
00547 FF29 A6 00 LDA A 0,X GET DATA
00548 FF2B FF A18C STX XSAVE
00549 FF2E FE A1AA LDX XSAVE2 PTR TO NEW LOCATION
00550 FF31 A7 00 STA A 0,X STORE DATA
00551 FF33 08 INX
00552 FF34 FF A1AA STX XSAVE2
00553 FF37 FE A18C LDX XSAVE AT END YET?
00554 FF3A BC A1A2 CPX STOP0
00555 FF3D 26 E9 BNE TOP1
00556 FF3F 20 22 BRA COMPR1 CHECK IF SUCCESSFUL MOVE
00557 *
00558 *
00559 FF41 B6 8501 SCHCK LDA A ACIADA CHECKS FOR S AT TELETYPE
00560 FF44 81 53 CMP A #'S S SIGNALS STOP OPERATION
00561 FF46 26 03 BNE CHCK
00562 FF48 7E FC2D JMP CONTRL
00563 FF4B 39 CHCK RTS
00564 *****
00565 *
00566 * ZERO CORE ROUTINE
00567 *
00568 * TYPE Z
00569 *
00570 * ZEROS MEMORY BETWEEN SPECIFIED ADDRESSES
00571 *
00572 FF4C 86 02 ZERDM LDA A #2
00573 FF4E 8D FD49 JSR PRADD PRINT/GET ADDRESS
00574 FF51 FE A1A0 LDX STRTO
00575 FF54 6F 00 ZERDA CLR 0,X ZERO MEMORY LOCATION
00576 FF56 BC A1A2 CPX STOP0 ALL LOCATIONS ZEROED?
00577 FF59 27 F0 BEQ CHCK
00578 FF5B 08 INX GO TO NEXT LOCATION
00579 FF5C 20 F6 BRA ZERDA

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00581 .....
00582 *
00583 *      COMPARE ROUTINE
00584 *
00585 *      TYPE C
00586 *
00587 *      COMPARES VALUES OF MEMORY OF ORIGINAL
00588 *      MEMORY TO NEW MEMORY. IF VALUES NOT
00589 *      EQUAL ERROR MESSAGE OF FORM--
00590 *      M ERR, LOCATION, INCORRECT VALUE,
00591 *      CORRECT VALUE<ORIGINAL>-- IS PRINTED.
00592 *
00593 *
00594 FF5E 86 03 COMPAR LDA A #3      ADDRESSES TO PRINT
00595 FF60 BD FD49 JSR PRADD      PRINT/GET ADDRESSES
00596 FF63 FE A1A0 COMPRI LDX STRT0  STARTING ADDRESS
00597 FF66 09      DEX
00598 FF67 A6 01 BEG0  LDA A 1,X    ORIGINAL VALUE
00599 FF69 08      INX
00600 FF6A FF A18C STX XSAVE    PTR TO ORIGINAL MEMORY
00601 FF6D FE A1A4 LDX STRT1    PTR TO NEW MEMORY
00602 FF70 E6 00  LDA B 0,X      NEW BYTE
00603 FF72 11      CBA          SAME AS OLD?
00604 FF73 27 1D BEQ BEG1        YES
00605 FF75 CE FFA8 LDX #MMES    PRINT ERROR MESSAGE
00606 FF78 BD FE5C JSR PDATA
00607 FF7B CE A1A4 LDX #STRT1  ADDRESS OF ERROR
00608 FF7E BD FE46 JSR OUT4HS
00609 FF81 FE A1A4 LDX STRT1    WRONG VALUE
00610 FF84 BD FE48 JSR OUT2HS
00611 FF87 FE A18C LDX XSAVE    ORIGINAL VALUE
00612 FF8A BD FE48 JSR OUT2HS
00613 FF8D 8D B2 BSR SCHCK      $ INPUT?
00614 FF8F FE A1A4 LDX STRT1
00615 FF92 08 BEG1 INX
00616 FF93 FF A1A4 STX STRT1
00617 FF96 FE A18C LDX XSAVE
00618 FF99 BC A1A2 CPX STOP0    AT END OF SPEC. MEMORY?
00619 FF9C 26 C9 BNE BEG0
00620 FF9E 39      RTS
00621 *
00622 FF9F 0D CRLF FCB $D,$A,$14.4
00623 FFA3 0D MTAPE1 FCB $D, /, /S, /1.4 PUNCH FORMAT
00624 FFA8 4D MMES FCC /M ERR /
00625 FFAE 04      FCB 4
00626 FFAF 53 MS9 FCB /S, /9.4

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PAGE 015 KBTMON
00628
00629
00630
00631 FFB2 7F A19F INITIAL CLR NOACIA
00632 FFB5 CE FFF4 LDX #RTIDFT
00633 FFB8 FF A1FE STX VNMI DEFAULT NMI TO RTI
00634 FFB8 FF A1FC STX VIRO DEFAULT IRQ TO RTI
00635 FFB8 FF A1FA STX VSWI DEFAULT SWI TO RTI
00636 FFC1 CE FC2D LDX #CONTRL
00637 FFC4 FF A190 STX XBRNH DEFAULT XBRNH
00638 FFC7 86 03 LDA A #$03
00639 FFC9 87 8500 STA A ACIACS INITIALIZE ACIA
00640 FFCC 86 51 LDA A #$51
00641 FFCE 87 8500 STA A ACIACS
00642 FFD1 86 8500 LDA A ACIACS CHECK IF ACIA IN SLOT 5
00643 FFD4 81 02 CMP A #$02
00644 FFD6 27 03 BEQ INITO
00645 FFD8 7C A19F INC NOACIA NO ACIA IN SLOT 5
00646 FFD8 8E A185 INITO LDS #STACK
00647 FFDE 8D F018 JSR PBINT INITIALIZE PANEL AND VECTORS
00648 FFE1 0E CLI
00649 FFE2 7E FC2D JMP CONTRL BRANCH TO CONTRL
00650
00651
00652 FFE5 FE A1FA SWI LDX VSWI GET SWI ADDRESS
00653 FFE8 6E 00 JMP 0,X
00654 FFEA FE A1FC IRQ LDX VIRO GET IRQ ADDRESS
00655 FFED 6E 00 JMP 0,X
00656 FFEF FE A1FE NMI LDX VNMI GET NMI ADDRESS
00657 FFF2 6E 00 JMP 0,X
00658 FFF4 3B RTIDFT RTI INTERRUPT DEFAULTS
00659
00660
00661 FFF8 SET INTERRUPT POINTERS
00662 FFF8 FFEA ORG $FFF8
00663 FFFA FFE5 FDB IRQ ADDRESS OF IRQ BRANCH
00664 FFFC FFEF FDB SWI ADDRESS OF SWI BRANCH
00665 FFFE FFB2 FDB NMI ADDRESS OF NMI BRANCH
00666 FFF8 FFB2 FDB INITIAL ADDRESS OF RESTART

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PAGE	016	KBTMON	ORG	RAM	
00667	A100		RMB	133	
00668	A100	0085	RMB		
00669	A185	0001	STACK RMB	1	STACK
00670	A186	0002	SP RMB	2	STACK POINTER
00671	A188	0001	CKSM0 RMB	1	CHECKSUM + CKSM
00672	A189	0001	BYTECT RMB	1	BYTE COUNT
00673	A18A	0001	XHI RMB	1	XREG HIGH
00674	A18B	0001	XLOW RMB	1	XREG LOW
00675	A18C	0002	XSAVE RMB	2	SAVE X REGISTER
00676	A18E	0002	XSAVE1 RMB	2	SAVE X REGISTER
00677	A190	0002	XBRNH RMB	2	GO BRANCH
00678	A192	0001	MCONT RMB	1	MAXIMUM COUNT
00679	A193	0001	TEMP RMB	1	TEMPORARY COUNT
00680	A194	0001	CKSM RMB	1	CHECKSUM
00681	A195	0002	STSAVE RMB	2	STACK SAVE
00682	A197	0002	SAVE X RMB	2	SAVE X REGISTER
00683	A199	0001	NOECD RMB	1	NO ECHO FLAG
00684	A19A	0001	BSAV RMB	1	SAVE B ACC
00685	A19B	0001	CHNGF RMB	1	RELOCATABLE LOAD FLAG
00686	A19C	0002	ADRET RMB	2	RETURN ADDRESS
00687	A19E	0001	DUMPF RMB	1	DUMP FLAG
00688	A19F	0001	NDACIA RMB	1	SIGNALS IF ACIA IN SLOT 5
00689	A1A0	0002	STRT0 RMB	2	ADDR OF PGM TO BE MOVED
00690	A1A2	0002	STOP0 RMB	2	END ADDR OF PGM TO BE MOVED
00691	A1A4	0002	STRT1 RMB	2	NEW BEGINNING ADDRESS
00692	A1A6	0002	STOP1 RMB	2	NEW ENDING ADDRESS
00693	A1A8	0002	OUTX RMB	2	TEMP X STORAGE FOR PLOOK
00694	A1AA	0002	XSAVE2 RMB	2	SAVE X REG
00695	A1AC	0001	ADDNUM RMB	1	NUMBER OF ADDRESSES TO GET
00696	A1AD	0001	ADDNM1 RMB	1	TEMP. STORAGE OF ADDNUM
00697			•		
00698			END		

TOTAL ERRORS 00000

!

MASTER CLEAR

MASTER LATCH

Fig. A-1.
Front panel push-button/LED board sch

NOTES:

UL's 1,2,3 & 4; 75454

UL 5 & 6; 7475

UL 7,8 & 11; 7408

UL 9 & 10; 74279

UL 12,13 & 14; 7404

UL 15,16,17 & 18; 7401

UL 19,20,21 & 22; 7474

UL 23; 7433

ALL R's: 3.3 K 1/4 WATT

LED's 0 THRU 7: HP-5032

Fig. A-1.

i-button/LED board schematic.