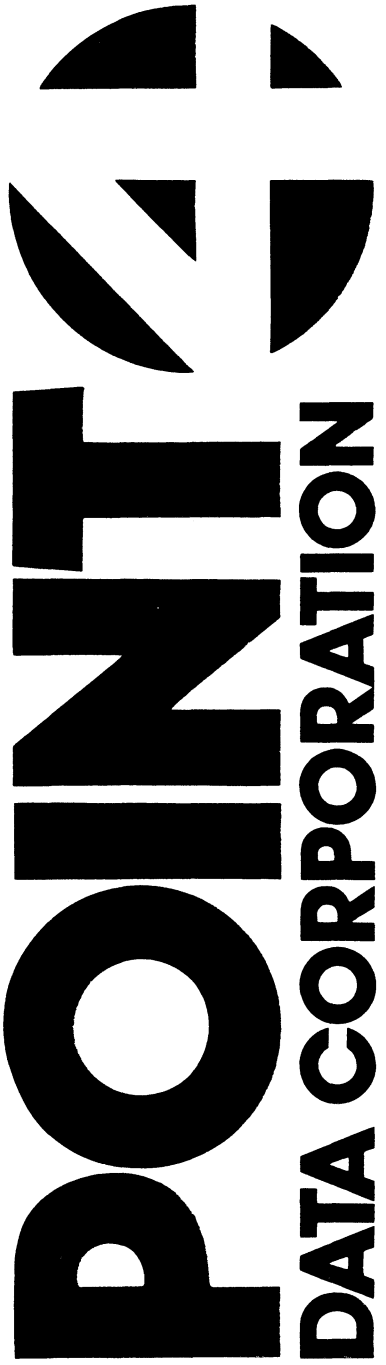
MARK 2E/4/4E

CPU Self-test/ MANIP Manual



POINT DATA CORPORATION

MARK 2E/4/4E

CPU SELF-TEST/ MANIP MANUAL

PROPRIETARY

Revision A

NOTICE

Every attempt has been made to make this manual complete, accurate and up-to-date. However, all information herein is subject to change due to updates. All inquiries concerning this manual should be directed to POINT 4 Data Corporation.

PROPRIETARY

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LIST OF EFFECTIVE PAGES

Changes, additions, and deletions to information in this manual are indicated by vertical bars in the margins or by a dot near the page number if the entire page is affected. A vertical bar by the page number indicates pagination rather than content has changed. The effective revision for each page is shown below.

Page	Rev	Page	Rev	Page	Rev
Cover	-				
Title thru vii	A				
1-1 thru 1-72	A				
2-1 thru 2-54	A				
Comment Sheet	A				
Mailer	-				
Back Cover	-				

PREFACE

The POINT 4 MARK 2E/4/4E CPU Self-Test/MANIP Manual is designed for maintenance and service technicians of MARK 2E, MARK 4, and MARK 4E systems. Its purpose is to provide information and instructions about the CPU Self-Test and the MANIP program.

The manual contains two sections: CPU Self-Test and MANIP. The section on CPU Self-Test provides instructions for accessing the CPU Self-Test, a detailed description of the CPU Self-Test and its operation, information on interpreting HALTS, and listings of the MARK 2E, MARK 4, and MARK 4E Self-Test programs. The section on MANIP provides instructions for accessing MANIP; a description of the MANIP commands, parameters, and functions; and listings of the MARK 2E, MARK 4, and MARK 4E MANIP programs.

Related Manuals

Related manuals include:

Title	Pub. Number
MARK 2E System Installation & Maintenance Manual	HM-082E-0060
MARK 4/4E System Installation & Maintenance Manual	HM-084-0063

CONTENTS

Tables

Section 1
CPU SELF-TEST

The MARK 2E/4/4E central processing unit (CPU) Self Test, has a comprehensive built-in diagnostic program that is contained in EPROM (Erasable Programmable Read-Only Memory). This diagnostic program is a self-test that tests all CPU logic and mapped memory and performs a comprehensive memory test of all main (on-board and expansion) memory. It does not test the Data Channel logic, but issues a test command to the disk controller and checks that the status is correct. It also does a loop-back test to the tape controller and all multiplexer boards installed.

Once the central processing unit (CPU) tests have been completed, the CPU relocates itself, then repeats. This process continues until an error is found, a key on the master terminal is pressed, or the reset button is pushed.

This section contains the following information and instructions on the CPU Self-Test:

- Accessing the CPU Self-Test
- CPU Self-Test Operation
- Interpreting HALTS
- Detailed Description of the CPU Self-Test
- MARK 2E Self-Test Listing
- MARK 4 Self-Test Listing
- MARK 4E Self-Test Listing

1.1 ACCESSING THE CPU SELF-TEST

The CPU Self-Test is accessed through the MANIP program as follows:

1. Press the reset switch. (The reset switch is located on the rear of the MARK 2E chassis and on the front panel of the MARK 4 and MARK 4E.)

   The program counter, four accumulators, carry flip flop and the MANIP prompt (->) are displayed.

2. Press V <RETURN> on the master terminal keyboard to load and run the hardware verify test.

This test will run in a continuous loop until a HALT occurs or until the operator presses <ESC> or the reset switch.

1.2 CPU SELF-TEST OPERATION

Once it has been accessed, the CPU Self-Test should operate as described below. (If it does not operate according to the following description, contact Hardware Technical Support at POINT 4 Data Corporation.)

If the master terminal is connected to the system, self-test messages are displayed on the screen in accordance with the stage of operation being completed. (If the master terminal is not connected, the program still operates but no messages are displayed.)

1. After preliminary tests are run, the following is displayed:

   ```
   MARK 2E [4/4E] CPU SELFTEST REV nn
   ```

2. After completion of the CPU test, the following is displayed:

   ```
   CPU OK
   ```

3. After completion of the MAP test, the following is displayed:

   ```
   MAP OK
   ```

4. After completion of the MEMORY test, the following is displayed:

   ```
   nnMB MEMORY OK
   ```

5. After completion of the DISK test, the following is displayed:

   ```
   DISK LOGIC OK
   ```

6. After completion of the TAPE test, the following is displayed:

   ```
   TAPE LOGIC OK
   ```

7. After completion of the MUX test, the following is displayed:

   ```
   nnPORTS OK
   ```

Self-Test relocates to another memory location and repeats the above. Main memory will be over written.

1.3 INTERPRETING HALTS

A HALT is a condition that brings the entire system to a standstill; it indicates an error. If a HALT occurs, information is displayed on the master terminal screen. The information includes the address of the HALT instruction +1 (the program counter), the four accumulators, and the state of the CARRY bit.

Dump the first few locations of memory. Normally, locations 0, 1, and 2 indicate the following:

- Location 0 indicates the starting location to which Self-Test has relocated itself, i.e., (0) real = 20000 virtual.
- Location 1 is the interrupt vector for the Illegal Interrupt test.
- Location 2 indicates the (real) address of the last test started.

There is one exception to this pattern. If an interrupt has occurred, word 0 contains the value of the program counter at the time of the interrupt.

By careful analysis of the program listing preceding the HALT, and the contents in the accumulators and temporary storage locations, it is usually possible to discover the reason for the error.

1.4 DETAILED DESCRIPTION OF THE CPU SELF-TEST

The various tests that comprise Self-Test are described below. The test descriptions are numbered; these numbers correspond to the circled numbers on the CPU Self-Test listings provided in Section 1.5 (MARK 2E), Section 1.6 (MARK 4), and Section 1.7 (MARK 4E).

1. Self-Test performs a few preliminary tests to detect certain specific failures. These tests include the compare instructions that will be used in subsequent tests, and the instructions used in the message subroutine.

2. The ALU and Data Bus test increments a counter, using an ISZ instruction, 64K times starting from 0. To test that it takes 64K counts before the counter overflows (resulting in a skip), it uses the four accumulators in four nested loops doing sixteen 1-bit shifts each. This test uses all possible 16-bit numbers as the "destination" input to the arithmetic-logic unit (ALU), and checks that carry propagation can occur from the least significant position up to any other position. It also tests the left and right shift capability for each bit.

3. The Arithmetic-Logic Unit (ALU) Source Operand test sums all numbers from 0 through 64K, and checks that the total is correct (to 16 bits). It uses all possible 16-bit numbers as the "source" input to the ALU.

4. An exhaustive test of all arithmetic-logic unit (ALU) instructions follows. It executes all arithmetic and logical instructions from 100000 = COM 0,0 through 177777 = ANDCS# 3,3,SBN and checks that the final result is correct. This test exercises all operations that the ALU is capable of, using a pseudo-random sequence of operands. It also uses all possible bit combinations in the instruction register (except MSB = 0).

5. The Page 0 and Base 3 Addressing test writes into each word of page zero that word's own address, using the page zero addressing mode (except when Self-Test is currently in page zero). It then reads the value back using the Base 3 addressing mode and confirms that it is correct.

6. The Relative, Base 2 and Indirect Addressing Modes test reads each word in the 256-word region addressable by relative addressing three different ways, and it checks that the same value is being read each way. It exercises all possible address displacements in memory-reference-type instructions. Each of these displacements is used with the same value in A2 and the program-counter. Different values in A2 and the program counter are tested when Self-Test relocates itself and repeats this test.

7. Self-Test then displays the message MARK 2E [4/4E] SELF-TEST REV. n.n. (This message is displayed only on the first pass. After Self-Test relocates and restarts, this message is suppressed.) CPU OK is displayed on the next line.

8. Self-Test now tests the Memory Map by writing all values from 1776 through 1 into all locations of the map RAMs. It then reads the values back and confirms that it is correct.

9. If Self-Test is currently located below the midpoint of available memory, the Memory Test tests all memory above itself; otherwise, it tests all memory below itself. (Exception: Locations 0 and 1 are always reserved for the current location of Self-Test and for the interrupt vector.) The Memory Test algorithm consists of the following four tests:

   a. Write a 1 into each bit of the first word, then change it to a 0, then change it back to a 1. Do the same for each successive word until all words contain 177777. Now test the first word, check that it contains 177777. Change it to 0, retest, then change it back to 177777. Repeat for each successive word. This algorithm ensures that between the time any word was set to 177777 and the time it is tested, all other words have been toggled back and forth between 0 and 177777.

   b. Repeat the algorithm of test 1 with the 1's and 0's interchanged.

   c. Repeat the algorithm using for each word its own address and its complement as the test value.

   d. Repeat the algorithm using a 73077 (HALT) as the test value. This ensures that if Self-Test ever jumps out of itself, it will HALT, saving the accumulators for failure analysis.

   When all the above memory tests have completed successfully, the following message is displayed:

   ```
   nnMB MEMORY OK
   ```

10. The disk controller is tested next by issuing a test command to the control board and testing the returned status for satisfactory completion.

    When the disk controller test is completed successfully, the following message is displayed:

    ```
    DISK LOGIC OK,
    ```

11. The tape controller portion of the peripherals interface board is tested by switching it into the test mode, writing out all bytes from 0 through 377, and checking that each byte is correctly stored and retrieved from the on-board tape loopback hardware.

12. Determine the number of asynchronous serial port boards and then test each port on each board by turning on the serial port diagnostic loopback feature.

    This causes all bytes from 0 through 377 inclusive to be written out to each port in turn. Each byte is checked to ascertain whether or not it is correctly stored and retrieved from the on-board loopback hardware.

    At the successful completion of the MUX test, the following is displayed:

        nnPORTS OK,

13. Self-Test now copies itself to a location slightly more than 20000 words below its current location, wrapping around to the top of memory if necessary. Since its initial location is 20000, the first move will bring it into upper RAM. (Straddling location zero is not allowed.)

1.5 MARK 2E SELF-TEST LISTING

The individual tests on the following MARK 2E CPU Self-Test listing are numbered to correlate with the test descriptions given in Section 1.4.

MARK 2E SELF-TEST LISTING (1 of 21)

```
- PAGE 4 -
;*****************************************************************
;POINT 4 DATA CORPORATION MARK 2E CPU SELF TEST PROGRAM
;EDITED FOR THE MARK 2E BY BOB WARD
;INITIAL RELEASE DECEMBER, 1986 - LAST EDITED APRIL 15, 1987
;4/15/87 - MODIFIED TO BE CALLED ONLY BY MANIP VIA THE "V"
;          COMMAND
;*****************************************************************

;                All Rights Reserved
;     Copyright (C) 1987, Point 4 Data Corporation
;
             1        .TXTM  1         ;SPECIFY TEXT PACKING LEFT TO RIGHT

         20000        .LOC   L.SELF    ;

   20000    401 SELFTEST:JMP .+1       ;

; TEST UNCONDITIONAL SKIP CAPABILITY

   20001 101020        MOVZ   0,0       ;TEST NON-SKIP
   20002 101021        MOVZ   0,0,SKP   ;TEST UNCONDITIONAL SKIP (WITH C = ZERO)
   20003  63077        HALT

   20004 125040        MOVO   1,1
   20005 125041        MOVO   1,1,SKP   ;UNCONDITIONAL SKIP (WITH C = 1)
   20006  63077        HALT                                                    (1)

   20007 152400        SUB    2,2
   20010 152401        SUB    2,2,SKP   ;UNCONDITIONAL SKIP (WITH ZERO RESULT)
   20011  63077        HALT

   20012 176000        ADC    3,3
   20013 176001        ADC    3,3,SKP   ;UNCONDITIONAL SKIP (WITH NON-ZERO RESULT)
   20014  63077        HALT

; TEST SKIP USING CARRY CONDITION

   20015 101042        MOVO   0,0,SZC
   20016 101062        MOVC   0,0,SZC   ;SKIP ON ZERO CARRY
   20017  63077        HALT

   20020 101023        MOVZ   0,0,SNC
   20021 101063        MOVC   0,0,SNC   ;SKIP ON NON-ZERO CARRY
   20022  63077        HALT

; TEST SKIP USING (ZERO OR NON-ZERO) RESULT CONDITION

   20023 102004        ADC    0,0,SZR
   20024 102404        SUB    0,0,SZR   ;SKIP ON ZERO RESULT, USING A0
   20025  63077        HALT

   20026 126405        SUB    1,1,SNR
   20027 125405        INC    1,1,SNR   ;SKIP ON NON-ZERO RESULT, USING A1
   20030  63077        HALT

   20031 152004        ADC    2,2,SZR
   20032 150004        COM    2,2,SZR   ;SKIP ON ZERO RESULT, USING A2
   20033  63077        HALT
```

```
---
   20034 176004       ADC    3,3,SZR
   20035 175404       INC    3,3,SZR  ;SKIP ON ZERO RESULT, USING A3
   20036  63077       HALT

; TEST COMBINED SKIP CONDITION (BOTH NON-ZERO OR EITHER ZERO)

   20037 126027       ADCZ   1,1,SBN  ;RESULT = NON-ZERO, BUT C = ZERO
   20040 126407       SUB    1,1,SBN  ;RESULT = ZERO, BUT C = NON-ZERO
   20041 126007       ADC    1,1,SBN  ;RESULT AND CARRY BOTH NON-ZERO
   20042  63077       HALT

   20043 152040       ADCO   2,2      ;RESULT = NON-ZERO, CARRY = NON-ZERO
   20044 152410       SUB#   2,2      ;SHOULD NOT CHANGE RESULT (BECAUSE #)
   20045 151030       MOVZ#  2,2      ;SHOULD NOT CHANGE CARRY (BECAUSE #)
   20046 151006       MOV    2,2,SEZ  ;SKIP IF EITHER ZERO
   20047    402       JMP    .+2      ;JUMP OVER HALT IF NO SKIP
   20050  63077       HALT

; TEST SOME LOAD AND ALU INSTRUCTIONS

   20051  20450       LDA    0,C0     ;LOAD A0 = 0
   20052 126400       SUB    1,1      ;SET A1 = 0
   20053 106414       SEQ    0,1
   20054  63077       HALT

   20055  30443       LDA    2,C1     ;LOAD A2 = 1
   20056 176520       SUBZL  3,3      ;SET A3 = 1
   20057 156414       SEQ    2,3                                          (1)
   20060  63077       HALT

   20061  20441       LDA    0,CM1    ;LOAD A0 = 177777 (-1)
   20062 152000       ADC    2,2      ;SET A2 = 177777 (-1)
   20063 112414       SEQ    0,2
   20064  63077       HALT

   20065  24436       LDA     1,CM2   ;LOAD A1 = 177776 (-2)
   20066 176120       ADCZL  3,3      ;SET A3 = 177776 (-2)
   20067 136414       SEQ    1,3
   20070  63077       HALT

   20071  34433       LDA    3,C100K  ;LOAD A3 = 100000
   20072 102620       SUBZR  0,0      ;SET A0 = 100000
   20073 162414       SEQ    3,0
   20074  63077       HALT

   20075  30430       LDA    2,M100K  ;LOAD A2 = 77777
   20076 126220       ADCZR  1,1      ;SET A1 = 77777
   20077 146414       SEQ    2,1
   20100  63077       HALT

   20101 102120       ADCZL  0,0      ;A0 = 177776, C = 1
   20102 101112       MOVL#  0,0,SZC  ;TEST MSB: SHOULD BE = 1
   20103 101212       MOVR#  0,0,SZC  ;TEST LSB: SHOULD BE = 0
   20104  63077       HALT
   20105 101302       MOVS   0,0,SZC  ;TEST C = 1: SWAP SHOULD NOT AFFECT CARRY
   20106 101362       MOVCS  0,0,SZC  ;COMPLEMENT CARRY, NOW TEST C = 0
   20107  63077       HALT

   20110 126520       SUBZL  1,1      ;A1 = 1, C = 0
```

```
---
   20111 125113         MOVL#  1,1,SNC  ;TEST MSB: SHOULD BE = 0
   20112 125213         MOVR#  1,1,SNC  ;TEST LSB: SHOULD BE = 1
   20113  63077         HALT
   20114 125303         MOVS   1,1,SNC  ;TEST C = 0: SWAP SHOULD NOT AFFECT CARRY
   20115 125363         MOVCS  1,1,SNC  ;COMPLEMENT CARRY, NOW TEST C = 1
   20116  63077         HALT
   20117    417         JMP    TSWAP

   20120      1 C1:     1
   20121      0 C0:     0
   20122 177777 CM1:    -1
   20123 177776 CM2:    -2
   20124 100000 C100K:100000
   20125  77777 M100K:77777
   20126 100000 B0:     100000
   20127  40000 B1:     40000
   20130  20000 B2:     20000
   20131  10000 B3:     10000
   20132   4000 B4:     4000
   20133   2000 B5:     2000
   20134   1000 B6:     1000
   20135    400 B7:     400

; TEST EACH SWAP INPUT TO SHIFTER

   20136  20770 TSWAP:LDA    0,B0
   20137 105300         MOVS   0,1
   20140 131300         MOVS   1,2                                          (1)
   20141 106414         SEQ    0,1
   20142 112414         SEQ    0,2
   20143  63077         HALT

   20144  24763         LDA    1,B1
   20145 135300         MOVS   1,3
   20146 161300         MOVS   3,0
   20147 136414         SEQ    1,3
   20150 122414         SEQ    1,0
   20151  63077         HALT

   20152  30756         LDA    2,B2
   20153 141300         MOVS   2,0
   20154 115300         MOVS   0,3
   20155 142414         SEQ    2,0
   20156 156414         SEQ    2,3
   20157  63077         HALT

   20160  34751         LDA    3,B3
   20161 171300         MOVS   3,2
   20162 145300         MOVS   2,1
   20163 172414         SEQ    3,2
   20164 166414         SEQ    3,1
   20165  63077         HALT

   20166  20744         LDA    0,B4
   20167 111300         MOVS   0,2
   20170 155300         MOVS   2,3
   20171 112414         SEQ    0,2
   20172 116414         SEQ    0,3
   20173  63077         HALT
```

```
---

20174  24737        LDA    1,B5
20175 121300        MOVS   1,0
20176 111300        MOVS   0,2
20177 122414        SEQ    1,0
20200 132414        SEQ    1,2
20201  63077        HALT

20202  30732        LDA    2,B6
20203 155300        MOVS   2,3
20204 165300        MOVS   3,1
20205 156414        SEQ    2,3
20206 146414        SEQ    2,1
20207  63077        HALT

20210  34725        LDA    3,B7
20211 165300        MOVS   3,1
20212 121300        MOVS   1,0
20213 166414        SEQ    3,1
20214 162414        SEQ    3,0
20215  63077        HALT
```

(1)

```
; A FEW MORE BASIC ALU TESTS

20216 102001 STALU:ADC    0,0,SKP  ;A0 = 177777
20217  63077        HALT             ;UNCONDITIONAL "SKP" FAILED TO SKIP
20220 126424        SUBZ   1,1,SZR  ;A1=0
20221  63077        HALT
20222 152000        ADC    2,2
20223 151404        INC    2,2,SZR  ;A2=0
20224  63077        HALT
20225 176000        ADC    3,3
20226 162415        SNE    3,0      ;A3,A0 SHOULD = 177777
20227 132414        SEQ    1,2      ;A1,A2 SHOULD = 0
20230  63077        HALT

; A FEW BASIC JMP, LDA, STA, ISZ TESTS USING RELATIVE ADDRESSING

20231  20405        LDA    0,.+5
20232 116414        SEQ    0,3
20233  63077        HALT             ;A0 & A3 SHOULD = 177777
20234  30670        LDA    2,C100K
20235 102621        SUBZR  0,0,SKP
20236 177777        177777
20237 112414        SEQ    0,2
20240  63077        HALT             ;A0 & A2 SHOULD = 100000
20241    402        JMP    .+2       ;TEST JMP REL.
20242  63077        HALT             ;SHOULD JUMP OVER THIS
20243  40401        STA    0,.+1
20244  63077 COM00:HALT             ;PGM CHANGES TO 100000=COM 0,0
20245 112415        SNE    0,2
20246  63077        HALT             ;A0 SHOULD = 77777, A2 = 100000
20247 100000        COM    0,0
20250  24774        LDA    1,COM00
20251 112415        SNE    0,2
20252 132414        SEQ    1,2
20253  63077        HALT             ;A0, A1, A2 SHOULD = 100000
20254   4403        JSR    JMP3      ;TEST INSTRS. USED IN "TYPE" S\R
20255  63077 HLT1: 63077
```

(2)

```
---
   20256  77077 HLT2: 77077
   20257  54002 JMP3: STA    3,2       ;LOC. 2 --> LAST TEST BEGUN
   20260  25400        LDA    1,0,3
   20261  20774        LDA    0,HLT1
   20262 106414        SEQ    0,1
   20263  63077        HALT              ;A0 & A1 SHOULD = 63077 = (HLT1)
   20264 175420        INCZ   3,3
   20265  25400        LDA    1,0,3
   20266  20770        LDA    0,HLT2
   20267 106414        SEQ    0,1                                          (2)
   20270  63077        HALT              ;A0 & A1 SHOULD = 77077 = (HLT2)
   20271    402        JMP    TISZ

   20272      1 CNTR: 1

   20273 102400 TISZ: SUB    0,0
   20274  40776        STA    0,CNTR
   20275  10775        ISZ    CNTR      ;TEST ISZ AND DSZ INSTR'S
   20276  14774        DSZ    CNTR
   20277  63077        HALT
   20300  14772        DSZ    CNTR
   20301  10771        ISZ    CNTR
   20302  63077        HALT
-------------------------------------------------------------------------
; ALU TEST: CALCULATE CHECKSUM IN A3 BASED UPON EXECUTION OF ALL
; POSSIBLE ALU INSTRUCTIONS, THEN COMPARE WITH CANNED VALUE (X)

   20303 102020 TALU: ADCZ   0,0       ;GENERATE 177777
   20304  41400        STA    0,+0,3    ;STORE 177777 AT TPWD
   20305 177240        ADDOR  3,3       ;COMPLEMENT MSB
   20306 102220        ADCZR  0,0       ;GENERATE 77777                  (3)
   20307  41400        STA    0,+0,3    ;STORE 77777 ... AT TPWD IF 32KW
                                        ;            ... AT (TPWD + 100000) .. OR,
                                        ;            ... (TPWD - 100000) IF 64KW
   20310   4451        JSR    PIKUP     ;(SKIPS NEXT WORD)
                       ;
   20311  42263 X:     42263  ;CHECKSUM FOR "EXHAUSTIVE ALU TEST"
-------------------------------------------------------------------------
; EXHAUSTIVE TEST OF ALL ALU INSTRUCTIONS

   20312 176220        ADCZR  3,3       ;A3 = 77777 (ARBITRARY INITIAL COND. )
   20313 171300        MOVS   3,2       ;A2 = 177577
   20314 145520        INCZL  2,1       ;A2 = 177401
   20315 102620        SUBZR  0,0       ;A0 = 100000
   20316  40401        STA    0,.+1

   20317  63077 ALUI: HALT              ;CYCLES THROUGH ALL ALU INSTR.   (4)
   20320 147100        ADDL   2,1       ; \
   20321 123100        ADDL   1,0       ;  } FOLD RESULT INTO A3
   20322 117100        ADDL   0,3       ; /
   20323  10774        ISZ    ALUI      ;MODIFY INSTRUCTION; ALL DONE ?
   20324    773        JMP    ALUI      ;  NO, CONTINUE
   20325  20764        LDA    0,X       ;  YES
   20326 162414        SEQ    3,0       ;IS FINAL RESULT CORRECT ?
   20327  63077        HALT              ;  NO, ALU ERROR
```

```
; BASE 3 ADDRESSING VS. PAGE ZERO

   20330   4431        JSR    PIKUP
---
   20331    764 REF1-L.SELF+400        ;
   20332 172032        SGE    3,2      ;IS SELF ABOVE PAGE ZERO ?
   20333    431        JMP    TJSR     ;  NO, SKIP PZ TEST
   20334 176520        SUBZL  3,3      ;SET UP FOR PAGE ZERO TEST
   20335  20002        LDA    0,2
   20336  20777        LDA    0,.-1
   20337  40403        STA    0,LDA0
   20340 175400 B3LP:  INC    3,3      ;  INCREMENT BY 1 WORD
   20341  55400        STA    3,0,3    ;INTO EACH WORD WRITE ITS OWN ADDRESS

   20342  20002 LDA0:  LDA    0,2      ;*******GETS MODIFIED BY PROGRAM******
   20343 116414        SEQ    0,3      ;DID WE GET BACK WHAT WE WROTE?
   20344  63077        HALT            ;  NO                                  (5)
   20345  10775        ISZ    LDA0     ;MODIFY THE LOAD INSTRUCTION
   20346  20410        LDA    0,K377
   20347 162032        SGE    3,0      ;IS A3 < 377
   20350    770        JMP    B3LP     ;  NO, REPEAT LOOP
   20351    413        JMP    TJSR     ;YES, GO ON TO NEXT TEST
   20352   4731 JTALU:JSR    TALU
   20353  77777 TPWD:  77777
   20354    125 K125:  125
   20355      0 FLG1:  0
   20356    377 K377:  377
   20357 177600 CM200:-200
   20360  20205 ADR:   LDREL-200       ;USED IN RELATIVE ADDRESSING TEST

; SUB-ROUTINE TO PICK UP POINTER TO CENTRAL REFERENCE POINT

   20361  54002 PIKUP:STA    3,2      ;LOC. 2 --> LAST TEST STARTED
   20362  31400        LDA    2,0,3    ;LOAD PARAMETER WORD
   20363   5401        JSR    1,3      ;SKIP-RETURN WITH POINTER TO "REF1"
          20364 REF1= .               ;REFERENCE POINT USED FOR ADDRESSING EXTENSION
---
; BASE 2, RELATIVE, AND INDIRECT ADDRESSING - ALL WITHIN +-200 OF HERE

   20364   4775 TJSR:  JSR    PIKUP
   20365     21        LDREL-REF1
   20366 173000        ADD    3,2      ;CALC. LOC. OF "LDREL"
   20367  20770        LDA    0,CM200
   20370 143040        ADDO   2,0
   20371  40767        STA    0,ADR    ;SET UP "ADR" = LDREL - 200
   20372  35200        LDA    3,-200,2
   20373  20777        LDA    0,.-1    ;PICK UP BASE 2 INSTR.
   20374  34600        LDA    3,.-200
   20375  34777        LDA    3,.-1    ;PICK UP REL. ADDR. INSTR.
   20376  40403 SETAD:STA    0,LDAB2  ;SET UP BASE 2 INSTRUCTION
   20377  54406        STA    3,LDREL  ;SET UP REL. ADDR. INSTR.              (6)
   20400  24757        LDA    1,CM200
   20401  35200 LDAB2:LDA    3,-200,2 ;*** GETS MODIFIED BY PROGRAM ***
   20402  22756        LDA    0,@ADR
   20403 116414        SEQ    0,3      ;A0 = INDIR., A3 = BASE 2 ADDRESSING
   20404  63077        HALT            ;THEY DON'T MATCH !?
   20405  34600 LDREL:LDA    3,.-200  ;*** GETS MODIFIED BY PROGRAM ***
   20406 116414        SEQ    0,3
   20407  63077        HALT
   20410  10750        ISZ    ADR      ;INCREMENT INDIRECT ADDRESS
   20411  10770        ISZ    LDAB2    ;AND BASE 2 LOAD INSTRUCTION,
   20412  10773        ISZ    LDREL    ;AND RELATIVE LOAD INSTRUCTION
   20413 125404        INC    1,1,SZR  ;HAVE WE TESTED 200 LOCATIONS ?
```

```
---
   20414    765        JMP    LDAB2    ;  NOT YET, REPEAT LOOP
   20415  35000        LDA    3,0,2    ;PREPARE FOR 2ND 200 LOCATIONS
   20416  20777        LDA    0,.-1    ;PICK UP BASE 2 INSTR.
   20417  34400        LDA    3,.      ;PICK UP REL. ADDR. INSTR.
   20420 101002        MOV    0,0,SZC  ;HAVE WE DONE 2ND PASS ALREADY ?
   20421    755        JMP    SETAD    ;  NO, DO IT NOW
```

(6)

```
; CHECK FOR PIB ON FIRST PASS OF SELFTEST

   20422  20733 FRST: LDA    0,FLG1
   20423 101014        SKZ    0,0      ;FIRST PASS?
   20424    463        JMP    CPUOK    ;  NO
   20425 102000        ADC    0,0      ;  YES, SET FLAG
   20426  40727        STA    0,FLG1
   20427  20725 IOCK: LDA    0,K125   ;CHECK IF TAPE IS PRESENT
   20430  24726        LDA    1,K377
   20431  61072        DOA    0,72     ;TURN ON TAPE LOOPBACK
   20432  61062        DOA    0,62     ;SEND BYTE TO TAPE
   20433  65000        DOA    1,0      ;CLEAR BUSS
   20434  64461        DIA    1,61     ;GET BACK BYTE
   20435 106415        SNE    0,1      ;SAME AS SENT ?
   20436    403        JMP    TST0     ;  YES, PIB PRESENT
   20437 102000        ADC    0,0      ;  NO, NO TAPE
   20440  40527        STA    0,FLG2
   20441  20713 TST0: LDA    0,K125
   20442  61070        DOA    0,70     ;TURN ON LOOPBACK
   20443  61013        DOA    0,13     ;SEND CHARACTER
   20444 152400        SUB    2,2
   20445  50465        STA    2,DLAY+1 ;CLEAR DELAY COUNTER
   20446  30463        LDA    2,DLAY   ;DELAY LOOP
   20447  10463        ISZ    DLAY+1
   20450    777        JMP    .-1
   20451 151404        INC    2,2,SZR
   20452    775        JMP    .-3
   20453  24703        LDA    1,K377
   20454  65000        DOA    1,0      ;CLEAR BUSS
   20455  64413        DIA    1,13     ;GET BACK CHARACTER
   20456  61071        DOA    0,71     ;LOOPBACK OFF
   20457 106415        SNE    0,1      ;CHARACTER SAME AS SENT ?
   20460    410        JMP    M2EST    ;  YES
   20461  20506        LDA    0,FLG2   ;  NO
   20462 101014        SKZ    0,0      ;WAS TAPE ALSO BAD ?
   20463    402        JMP    SETF     ;  YES, NO PIB
   20464  63077        HALT            ;  NO, PORT 1 BAD !
   20465 102000 SETF: ADC    0,0      ;NO PIB, THEREFORE ...
   20466  40543        STA    0,NIOF   ; ... RUN SELFTEST WITHOUT ...
   20467    543        JMP    TMAP     ; ... PRINTOUT OR I/O TESTS

   20470   4500 M2EST:JSR    PRINT    ;
   20471   6412       .TXT   "<15><12>
   20472  46501 MA
   20473  51113 RK
   20474  20062  2
   20475  42440 E
   20476  51505 SE
   20477  46106 LF
   20500  52105 TE
   20501  51524 ST
   20502  20122  R
```

(7)

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---
   20503  42526 EV
   20504  27040 .
   20505  30456 1.
   20506  30400 1"



   20507  20522 CPUOK:LDA    0,NIOF   ;                                    (7)
   20510 101014        SKZ    0,0
   20511    521        JMP    TMAP
   20512   4456        JSR    PRINT    ;CPU OK
   20513   6412        .TXT   "<15><12>
   20514  41520 CP
   20515  52440 U
   20516  47513 OK
   20517  26000 ,"

   20520    512        JMP    TMAP

   20521    640 JPKP: JMP    PIKUP    ;
-------------------------------------------------------------------------
; SOME SUBROUTINES USED FOR PRINT AND PORT 0 TEST

   20522  20407 PRNTR:LDA    0,DLAY   ;
   20523 101404        INC    0,0,SZR
   20524    777        JMP    .-1
   20525  10405        ISZ    DLAY+1
   20526    774        JMP    PRNTR    ;
   20527  61071        DOA    0,71
   20530   1400        JMP    0,3

   20531 177774 DLAY: -4
   20532      0        0
   20533      0 CSAV: 0

   20534 151100 TIMO: MOVL   2,2
   20535  50776        STA    2,CSAV
   20536  30773        LDA    2,DLAY
   20537 151404        INC    2,2,SZR
   20540    777        JMP    .-1
   20541  10771        ISZ    DLAY+1                                       (MISC)
   20542    402        JMP    .+2
   20543  63077        HALT
   20544 152400        SUB    2,2
   20545  50765        STA    2,DLAY+1
   20546  30765        LDA    2,CSAV
   20547 151200        MOVR   2,2
   20550   1400        JMP    0,3

   20551  20000 .SELF:L.SELF          ;
   20552  21632 END.: END
   20553      1 CNT:  1               ;GENERAL PURPOSE COUNTER
   20554    100 K100: 100             ;OCTAL 64
   20555    200 C200: 200             ;OCTAL 128
   20556   1776 C1776:1776           ;OCTAL 1022
   20557   1400 C1400:1400           ;OCTAL 768
   20560  77400 C177L:77400
   20561 177700 CN100:-100           ;OCTAL -64
   20562   1000 C1K:  1000           ;OCTAL 512
```

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---
   20563    2000 K2K:  2000            ;OCTAL 1024
   20564    1776 PGADR:1776            ;MAP RAM PHYSICAL PAGE ADDRESS
   20565    1000 MRNT: 1000
   20566   77377 TEMP3:77377
   20567       0 FLG2: 0

; PRINT-OUT SUBROUTINE...ALSO TESTS PORT 0

   20570   61070 PRINT:DOA    0,70      ;TURN ON MUX LOOPBACK
   20571   25400 PRNT1:LDA    1,0,3     ;GET 2 CHARACTERS
   20572  102400       SUB    0,0
   20573   40737       STA    0,DLAY+1
   20574  175420       INCZ   3,3       ;BUMP CHARACTER POINTER
   20575   54771       STA    3,TEMP3   ;SAVE CHARACTER POINTER
   20576   20762 PRNT2:LDA    0,C177L   ;DO LEFT BYTE 1ST
   20577  123705       ANDS   1,0,SNR   ;TERMINATOR ?
   20600     722       JMP    PRNTR     ;YES, EXIT
   20601   70410 PRNTL:DIA    2,10      ;NO, GET PORT 0 STATUS
   20602  151202       MOVR   2,2,SZC   ;ANYTHING IN REC. REG ?
   20603   63077       HALT             ;  YES, ABORT
   20604  151212       SKE    2,2       ;XMIT REG FULL ?
   20605     404       JMP    OPCHR     ;  NO, XMIT CHARACTER
   20606    4726       JSR    TIMO      ;  YES, CHECK TIMEOUT
   20607  151100       MOVL   2,2       ;RECONSTITUTE CARRY ...
   20610     771       JMP    PRNTL     ; ... AND CONTINUE WAIT
   20611   61011 OPCHR:DOA    0,11      ;OUTPUT CHARACTER
   20612  151100       MOVL   2,2       ;RESTORE CARRY
   20613  152460       SUBC   2,2
   20614   50716       STA    2,DLAY+1  ;RESET DELAY COUNTER
   20615   70410 RDSTA:DIA    2,10      ;READ PORT 0 STATUS
   20616  151212       SKE    2,2       ;RECEIVER EMPTY ?
   20617     403       JMP    GCHAR     ;  NO, GO TO GET CHARACTER
   20620    4714       JSR    TIMO      ;  YES, CHECK FOR TIMEOUT
   20621     774       JMP    RDSTA
   20622   70411 GCHAR:DIA    2,11      ;GET CHARACTER
   20623  112414       SEQ    0,2       ;SAME AS SENT ?
   20624   63077       HALT             ;  NO, ERROR ! AC0 = SHOULD BE, AC2 = IS
   20625   34741       LDA    3,TEMP3   ;RESTORE CHARACTER POINTER
   20626  125362       MOVCS  1,1,SZC   ;  YES, CONTINUE. DONE BOTH ?
   20627     747       JMP    PRNT2     ;   NO, NEXT CHARACTER

   20630     741       JMP    PRNT1     ;    YES, NEXT 2 CHARACTERS

   20631       0 NIOF:0                ;NO I/O FLAG
```

MISC

```
; TEST MEMORY MAPPING RAMS (93422s)
; WRITE ALL VALUES FROM 1776 THROUGH 1 INTO ALL LOCATIONS OF
; MAP RAMS. READ BACK, AND COMPARE. REPEAT FOR ALL 4 MAPS.

   20632    4667 TMAP: JSR    JPKP      ;MEMORY LOCATION 2 = NEXT ADDRESS
   20633       0       0
   20634  102400       SUB    0,0       ;CLEAR A0
   20635   40730       STA    0,MRNT    ;MRNT=0 (MAP RAM NEXT TABLE LOAD)
   20636   20720 TMP1: LDA    0,C1776   ;A0=1776 OCTAL (HIGHIST PHYSICAL PAGE ADDRESS)
   20637   40725       STA    0,PGADR   ;STORE 1776 TO PGADR (MAP RAM PHYSICAL PAGE
                                        ;ADDRESS)
                                        ;NOW SET UP MAP RAM TABLE
   20640   20724 TMP2: LDA    0,PGADR   ;GET CURRENT PHYSICAL PAGE ADDRESS (DATA TO
                                        ;BE WRITTEN TO MAP RAMS)
```

8

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---
   20641  24720        LDA    1,CN100  ;A1=-100 TO FILL 64 WORDS OF MAP TABLE
   20642  30721        LDA    2,K2K    ;A2=2000 OCTAL (USED TO INC LOG ADDR BY 1)
                                       ;LOGICAL ADDRESS DETERMINES MAP RAM ADDRESS
   20643   4551        JSR    JJJJM    ;A3=END OF SELFTEST+1 (START OF MAP TABLE)

   20644  41400 TMP3:  STA    0,0,3    ;MAKE MAP TABLE ENTRY
   20645 175400        INC    3,3      ;BUMP MAP TABLE ENTRY POINTER
   20646 143000        ADD    2,0      ;ADJUST TO NEXT LOGICAL PAGE (MAP RAM
                                       ;ADDRESS)
   20647 125404        INC    1,1,SZR  ;TEST FOR DONE
   20650    774        JMP    TMP3     ;NOT YET

   20651  20714        LDA    0,MRNT   ;GET MAP TO LOAD
   20652  61002        DOA    0,2      ;SELECT MAP FOR LOAD
   20653   4541        JSR    JJJJM    ;A3=STARTING ADDRESS OF MAP TABLE
   20654  77002        DOC    3,2      ;LOAD MEMORY MAP

   20655  30677        LDA    2,K100   ;A2=100 OCTAL (64 DECIMAL)
   20656  50675        STA    2,CNT    ;INITIALIZE CNT (COUNTER) FOR 64 MAP
                                       ;ENTRIES
   20657 173000        ADD    3,2      ;A2=END OF PREVIOUSLY CREATED MAP TABLE
                                       ;(A3)+1
   20660  72402        DIC    2,2      ;READ MAP RAM CONTENTS AND PLACE IT
                                       ;STARTING AT A2

   20661  25400 TCHK:  LDA    1,0,3    ;FETCH CORRECT MAP RAM TABLE ENTRY
   20662  21000        LDA    0,0,2    ;FETCH ENTRY JUST READ                    (8)
   20663 106414        SEQ    0,1      ;COMPARE ?
   20664  63077        HALT            ;NO!  A0=CORRECT, A1=INCORRECT
   20665 175400        INC    3,3      ;BUMP POINTERS IN BOTH MAP TABLES
   20666 151400        INC    2,2      ;
   20667  14664        DSZ    CNT      ;DONE WITH TABLE COMPARISON?
   20670    771        JMP    TCHK     ;NO

   20671  14673        DSZ    PGADR    ;HAVE ALL POSSIBLE PHYSICAL ADDRESS VALUES
                                       ;BEEN WRITTEN?
   20672    746        JMP    TMP2     ;NO, TEST WITH THE NEXT LOWER ADDRESS

   20673  20672        LDA    0,MRNT   ;LOAD A0 WITH THE CURRENT MAP NUMBER
   20674  24661        LDA    1,C200   ;A1=200 OCTAL
   20675 123000        ADD    1,0      ;INCREMENT TO THE NEXT MAP
   20676  30664        LDA    2,C1K    ;A2=1000 OCTAL
   20677 112415        SNE    0,2      ;TESTED ALL FOUR MEMORY MAPS?
   20700    403        JMP    MAPOK    ;YES
   20701  40664        STA    0,MRNT   ;NO, STORE NEXT MAP TABLE LOAD VALUE
   20702    734        JMP    TMP1     ;

   20703  20726 MAPOK:LDA    0,NIOF   ;TEST NO I/O FLAG
   20704 101014        SKZ    0,0      ;ZERO?
   20705    413        JMP    SZMEM    ;NO, DON'T DO PRINT OUT
   20706   4662        JSR    PRINT    ;YES, PRINT MAP OK

   20707  20040 .TXT"<40><40>
   20710  46501 MA
   20711  50040 P
   20712  47513 OK
   20713  26000 ,"
                ;MAP OK TEXT
   20714    404        JMP    SZMEM
```

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   20715    653 JPRNT:JMP    PRINT

   20716  20713 LIOF: LDA    0,NIOF    ;A0=CONTENTS OF THE NO I/O FLAG
   20717   1400       JMP    0,3       ;RETURN TO CALLING ROUTINE

   20720  20476 SZMEM:LDA    0,MAPN    ;TIME TO TEST MEMORY WIDTH?
   20721 101004       MOV    0,0,SZR
   20722    502       JMP    TMEM-2    ;NO

; DETERMINE DEPTH OF SYSTEM MEMORY: 128KW, 256KW, 512KW OR 1MW
;                                   (256KB, 512KB,  1MB  OR 2MB)

   20723   4466 SIZEM:JSR    JSTB      ;SETUP MAP TABLE WITH LOGICAL PAGE=
                                       ;PHYSICAL PAGE
   20724   4451       JSR    CNGTB     ;ALTER LAST 4 TABLE ENTRIES
                                       ;NOTE: MAP IS NOW ACTIVATED

   20725  34470       LDA    3,C.20    ;A3=20 OCTAL.  ASSUME SYSTEM MEMORY CONSISTS
                                       ;OF 16 BLOCKS OF 64KW EACH (2MB)
   20726  30471       LDA    2,TOPWD   ;A2=177777 (HIGHEST LOGICAL MEMORY ADDRESS)
   20727 102400 SIZ1: SUB    0,0       ;CLEAR A0 (TEST VALUE)
   20730  41000       STA    0,0,2     ;STORE A0 AT LOGICAL ADDR CONTAINED IN A2
   20731  25000       LDA    1,0,2     ;READ STORED VALUE INTO A1
   20732 106414       SEQ    0,1       ;WRITE = READ?
   20733    427       JMP    SIZ3      ;NO
   20734 100000       COM    0,0       ;YES, COMPLEMENT THE TEST VALUE AND TRY
                                       ;AGAIN
   20735  41000       STA    0,0,2     ;STORE AGAIN AT THE SAME LOCATION          (8)
   20736  25000       LDA    1,0,2     ;READ AGAIN
   20737 106414       SEQ    0,1       ;WRITE = READ?
   20740    422       JMP    SIZ3      ;NO
                                       ;YES, RECORD MEMORY SIZE IN MSIZ
   20741  54457 SIZ2: STA    3,MSIZ    ;MSIZ=SYSTEM MEMORY SIZE IN TERMS OF 64KW
                                       ;BLOCKS (16, 8, 4 OR 2)
   20742  54454       STA    3,MAPN    ;
   20743   4407       JSR    SIZ4      ;PICK UP MESSAGE ADDRESS
   20744  20062       20062            ;<40><62>  2MB
   20745  20061       20061            ;<40><61>  1MB
   20746  27065       27065            ;<56><65> .5MB
   20747  27062       27062            ;<56><62> .2MB

   20750 177776 CN2:  -2               ;NEGATIVE 2 OCTAL
   20751 177774 MSGINDX:-4             ;NEGATIVE 4 OCTAL

   20752  20777 SIZ4: LDA    0,MSGINDX;LOAD A0 WITH INDEX POINTER (-4,-3,-2 OR
                                       ;-1)
   20753 117000       ADD    0,3       ;CALCULATE TEXT ADDRESS
   20754  21404       LDA    0,4,3     ;PICK UP MESSAGE
   20755  40555       STA    0,MOKMG+1;AND STORE IT
   20756 102400       SUB    0,0       ;CLEAR A0
   20757  61002       DOA    0,2       ;DISABLE MAP STATUS
   20760  62677       IORST            ;MAP OFF
   20761    443       JMP    TMEM-2    ;FINISHED

                                       ;MODIFY MESSAGE INDEX
   20762  20767 SIZ3: LDA    0,MSGINDX;LOAD A0 WITH INDEX POINTER TO SYSTEM
                                       ;MEMORY SIZE DESCRIPTOR TEXT
   20763 101400       INC    0,0       ;INCREMENT POINTER TO NEXT LOWER SIZE
```

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---
   20764  40765        STA    0,MSGINDX;STORE NEW INDEX POINTER
   20765  20574        LDA    0,M2000  ;A0=-2000
   20766 113000        ADD    0,2      ;DECREMENT LOGICAL ADDRESS BY 2K
   20767 175220        MOVZR  3,3      ;A3=A3/2.  DEVIDE SYSTEM MEMORY SIZE IN
                                       ;TERMS OF 64KW BLOCKS BY 2
   20770  20427        LDA    0,TOPWD  ;A0=177777
   20771 163004        ADD    3,0,SZR  ;DONE (A3=1)?
   20772    735        JMP    SIZ1     ;NO
   20773 175120        MOVZL  3,3      ;YES FORCE TO BE 2
   20774    745        JMP    SIZ2                                          (8)

   20775  54575 CNGTB:STA    3,MRET   ;SAVE RETURN ADDRESS TO CALLING PROGRAM
   20776  24753        LDA    1,MSGINDX;A1=-4
   20777   4415        JSR    JJJJM    ;A3=END OF SELFTEST+1 (START OF MAP TABLE)
   21000  20557        LDA    0,C100   ;A0=100 OCTAL (64 DECIMAL)
   21001  31474 CNGT1:LDA    2,74,3   ;CHANGE PHYSICAL ADDRESS IN LAST 4 MAP TABLE
   21002 113000        ADD    0,2      ;ENTRIS TO BE:
   21003  51474        STA    2,74,3   ;            0174  (A PHY PAGE IN 256KB)
   21004 101120        MOVZL  0,0      ;            0275  (A PHY PAGE IN 256-512KB)
   21005 175400        INC    3,3      ;            0476  (A PHY PAGE IN 512-1024KB)
   21006 125404        INC    1,1,SZR  ;            1077  (A PHY PAGE IN 1024-2048KB)
   21007    772        JMP    CNGT1    ;
   21010    541        JMP    CNGXT    ;RETURN VIA @MRET WITH MAP ON

   21011    562 JSTB: JMP    STBL     ;ELEVATOR TO STBL
   21012    703 JJPR: JMP    JPRNT    ;ELEVATOR TO PRINT
   21013    703 JLIOF:JMP    LIOF     ;ELEVATOR TO LIOF (LOAD ACCUMULATOR 0
                                       ;WITH THE CONTENTS OF THE NO I/O FLAG)
   21014    527 JJJJM:JMP    JJJMT    ;ELEVATOR TO MTBL (BEGINNING OF MAP TABLE)

   21015     20 C.20: 20              ;20 OCTAL (16 DECIMAL)
   21016      0 MAPN: 0               ;
   21017 177777 TOPWD:177777          ;LARGEST MEMORY ADDRESS
   21020      0 MSIZ: 0               ;
   21021 177401 CMT1: 177401          ;
   21022 173777 CMT2: 173777          ;
   21023      4 CMT3: 4               ;
```

```
; MEMORY TEST:  FIRST PASS: SET A BIT TO 1, SET IT TO 0, THEN SET
; IT BACK TO 1, THEN DO THE SAME TO NEXT BIT, ETC.
; SECOND PASS: TEST THAT THE BIT = 1, TOGGLE IT TO 0, RETEST,
; AND BACK TO 1, THEN DO SAME FOR NEXT BIT--
; THUS EACH BIT IS TESTED AFTER ALL OTHER BITS HAVE BEEN TOGGLED.
; THEN REPEAT THE WHOLE TEST WITH 0'S AND 1'S INTERCHANGED
; THIRD TEST: USE EACH WORD'S ADDRESS IN PLACE OF 0'S OR 1'S
; FOURTH TEST: USE 73077 HALT (HAS ODD PARITY) IN PLACE OF ADDRRESS

   21024 102400        SUB    0,0
   21025  40535        STA    0,MPNC
   21026   4763 TMEM: JSR    JSTB
   21027   4563        JSR    PKUP
   21030    615        END+200-REF2                                        (9)
   21031 173000        ADD    3,2      ;A2 = FIRST LOC. ABOVE SELF-TEST
   21032  21602        LDA    0,TOPWD-REF2,3
   21033 101220        MOVZR  0,0      ;MIDPOINT OF AVAILABLE RAM
   21034 142033        SLS    2,0      ;ARE WE CURRENTLY ABOVE MIDPOINT ?
   21035   4510        JSR    JSTL     ;YES, TEST LOWER MEMORY
   21036   4510        JSR    JSTH     ;NO, TEST UPPER PORTION
   21037  30516 MTEST:LDA    2,FIRST  ;FIRST PASS - SET UP MEMORY
```

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---
   21040 101003 LOOP1:MOV    0,0,SNC  ;IS THIS THE THIRD TEST ?
   21041 141000       MOV    2,0      ;  YES: USE ADDRESS
   21042  41000       STA    0,0,2
   21043 104000       COM    0,1
   21044  45000       STA    1,0,2    ;TOGGLE MEMORY WORD
   21045  41000       STA    0,0,2    ;TOGGLE BACK AGAIN
   21046 151400       INC    2,2
   21047 156032       SGE    2,3      ;ALL SET UP ?
   21050    770       JMP    LOOP1    ;  NOT YET
   21051  30504       LDA    2,FIRST  ;SECOND PASS - TEST MEMORY
   21052 101003 LOOP2:MOV    0,0,SNC  ;ARE WE ON THE THIRD TEST ?
   21053 141000       MOV    2,0      ;  YES, USE ADDRESS
   21054  25000       LDA    1,0,2
   21055 106414       SEQ    0,1
   21056    441       JMP    MERR     ;ERROR
   21057 104000       COM    0,1
   21060  45000       STA    1,0,2    ;TOGGLE MEMORY
   21061  25000       LDA    1,0,2    ;RETEST
   21062 124000       COM    1,1
   21063 106414       SEQ    0,1
   21064    433       JMP    MERR     ;ERROR
   21065  41000       STA    0,0,2    ;TOGGLE MEMORY WORD BACK AGAIN
   21066 151400       INC    2,2
   21067 156032       SGE    2,3      ;TESTED ALL LOCATIONS ?
   21070    762       JMP    LOOP2    ;  NO                              (9)
   21071 101466       INCC   0,0,SEZ  ;NOW PREPARE FOR NEXT TEST
   21072  20461       LDA    0,HALTI  ;GET THE HALT INSTRUCTION
   21073  24460       LDA    1,HALTI  ;GET 73077 INSTRUCTION
   21074 122014       ADC#   1,0,SZR  ;HAVE WE DONE FOUR TESTS?
   21075    742       JMP    MTEST    ;NO, DO NEXT TEST
   21076 102400       SUB    0,0
   21077  61002       DOA    0,2      ;DISABLE MAP
   21100  62677       IORST
   21101 102000       ADC    0,0
   21102  40465       STA    0,MTSF
   21103  14713       DSZ    MAPN     ;DONE ALL BLOCKS ?
   21104    402       JMP    .+2      ;NO
   21105    414       JMP    MPASS    ;YES, EXIT
   21106  34451       LDA    3,C100
   21107  24707       LDA    1,MAPN
   21110 124000       COM    1,1
   21111 102400       SUB    0,0
   21112 125405       INC    1,1,SNR
   21113    713       JMP    TMEM     ;TEST NEXT BLK
   21114 163000       ADD    3,0
   21115  40445       STA    0,MPNC
   21116    774       JMP    .-4

   21117  34677 MERR: LDA    3,MAPN
   21120  63077       HALT   ;A0=S\B, A1=IS, A2=ADDR, A3=MAP

   21121  20677 MPASS:LDA    0,MSIZ   ;
   21122  40674       STA    0,MAPN   ;RESTORE BLOCK COUNTER
   21123 102400       SUB    0,0      ;
   21124  40436       STA    0,MPNC   ;RESTORE MPNC:0

   21125   4666 MEMOK:JSR    JLIOF    ;A0:NIOF
   21126 101014       SKZ    0,0      ;
   21127    421       JMP    JDSKT    ;
```

```
---
   21130   4662        JSR    JJPR      ;MEMORY OK
   21131  20040 MOKMG:.TXT   "<40><40>
   21132  20040 <40><40>
   21133  46502 MB
   21134  20115  M
   21135  42515 EM
   21136  47522 OR
   21137  54440 Y
   21140  47513 OK
   21141  26000 ,"

   21142    406        JMP    JDSKT     ;

   21143    555 JJJMT:JMP    JJMTB     ;ELEVATOR TO MTBL (BEGINNING OF MAP TABLE)
   21144    646 JJJPR:JMP    JJPR      ;ELEVATOR TO PRINT
   21145    512 JSTL: JMP    STML      ;ELEVATOR TO STML
   21146    447 JSTH: JMP    STMH      ;ELEVATOR TO STMH
   21147    545 JMLD: JMP    MPLD      ;ELEVATOR TO MPLD
   21150    554 JDSKT:JMP    DISKT     ;ELEVATOR TO DISKT
   21151    533 CNGXT:JMP    STMLE     ;ELEVATOR TO STMLE (LOAD MAP TABLE AND
                                       ;ACTIVATE VIA @MRET)
   21152    641 JJLIO:JMP    JLIOF     ;ELEVATOR TO LIOF (LOAD ACCUMULATOR 0
                                       ;WITH THE CONTENTS OF THE NO I/O FLAG)

   21153  73077 HALTI:73077           ;HALT INSTRUCTION
   21154      2 C2:   2               ;2 OCTAL
   21155      1 FIRST:1               ;
   21156      1 LAST: 1               ;
   21157    100 C100: 100             ;100 OCTAL
   21160 177700 CM100:-100            ;NEGATIVE 100 OCTAL
   21161 176000 M2000:-2000           ;MINUS 2000 OCTAL (2K)
   21162      1 MPNC: 1               ;
   21163   2001 CINC: 2001            ;
   21164   2000 C2K:  2000            ;2048 IN OCTAL (2K)
   21165 175746 NWDS: L.SELF-END-200  ;
   21166 100000 MUSR: 100000          ;
   21167 177777 MTSF: 177777          ;
   21170      1 AC0S: 1               ;
   21171      1 AC1S: 1               ;
   21172  77077 MRET: 77077

   21173  54777 STBL: STA    3,MRET    ;SETUP MEMORY MAP TABLE FOR
                                       ;LOGICAL=PHYSICAL
   21174   4524        JSR    JJMTB     ;PICKUP MAP TABLE ADDRESS
   21175 102400        SUB    0,0       ;MTSF:A2:0
   21176  40771        STA    0,MTSF
   21177  24761        LDA    1,CM100   ;A1:-100
   21200  30763        LDA    2,CINC    ;PAGE INC. CONST.
   21201  41400 STLP: STA    0,0,3     ;MAKE TBL ENTRY
   21202 175400        INC    3,3
   21203 143000        ADD    2,0
   21204 125404        INC    1,1,SZR   ;DONE WITH TABLE ?
   21205    774        JMP    STLP      ;NO
   21206 102000        ADC    0,0       ;A0:177777
   21207  41400        STA    0,0,3     ;STOP END OF TABLE
   21210  34762        LDA    3,MRET
   21211   1400        JMP    0,3

   21212  54002 PKUP: STA    3,2
```

(9)

```
---
   21213  31400        LDA    2,0,3
   21214   5401        JSR    1,3
          21215 REF2=.

   21215  54755 STMH:  STA    3,MRET   ;SETUP TO TEST MEM ABOVE SELF
   21216  40752        STA    0,AC0S
   21217  50736        STA    2,FIRST
   21220   4500        JSR    JJMTB    ;PICKUP MAP TABLE ADDRESS
   21221  20743        LDA    0,C2K
   21222  24736        LDA    1,CM100
   21223    403        JMP    .+3
   21224 125400        INC    1,1
   21225 175400        INC    3,3
   21226 112443        SUBO   0,2,SNC  ;CALC 1ST PAGE ABOVE SELF
   21227    775        JMP    .-3
   21230  20732        LDA    0,MPNC
   21231  44740        STA    1,AC1S
   21232  30726        LDA    2,CM100
   21233 146400        SUB    2,1      ;DONT MAP OUT SELF
   21234  30727        LDA    2,CINC   ;PAGE INC. CONST.
   21235 124000        COM    1,1
   21236 143000        ADD    2,0
   21237 125404        INC    1,1,SZR
   21240    776        JMP    .-2
   21241 175400        INC    3,3
   21242  24727        LDA    1,AC1S                                    (9)
   21243  41400        STA    0,0,3
   21244 143000        ADD    2,0
   21245 175400        INC    3,3
   21246 125404        INC    1,1,SZR  ;DONE WITH TBL ?
   21247    774        JMP    .-4      ;NO
   21250   4450        JSR    JJMTB    ;PICKUP MAP TABLE ADDRESS
   21251 171000        MOV    3,2
   21252   4442        JSR    MPLD     ;LOAD MAP
   21253  34715        LDA    3,AC0S
   21254  20714        LDA    0,AC0S
   21255 102040        ADCO   0,0
   21256   2714        JMP    @MRET    ;ACTIVATE MAP ON RETURN

   21257 175400 STML:  INC    3,3      ;SETUP TO TEST MEM BELOW SELF
   21260  54712        STA    3,MRET
   21261  34704        LDA    3,NWDS
   21262 173000        ADD    3,2
   21263  50673        STA    2,LAST
   21264  20700        LDA    0,C2K    ;PAGE SIZE
   21265 126400        SUB    1,1
   21266   4432        JSR    JJMTB    ;PICKUP MAP TABLE ADDRESS
   21267    402        JMP    .+2
   21270 125400        INC    1,1
   21271 112443        SUBO   0,2,SNC  ;CALC LAST PAGE BELOW SELF
   21272    776        JMP    .-2
   21273 124000        COM    1,1      ;-(NO. PAGES)
   21274  20666        LDA    0,MPNC
   21275  30666        LDA    2,CINC   ;PAGE INC CONST
   21276 125405        INC    1,1,SNR
   21277    405        JMP    .+5
   21300  41400        STA    0,0,3    ;MAKE TABLE ENTRY
   21301 175400        INC    3,3
   21302 143000        ADD    2,0
```

```
---
   21303    773        JMP    .-5
   21304   4414 STMLE:JSR    JJMTB     ;PICKUP MAP TABLE ADDRESS
   21305 171000        MOV    3,2
   21306   4406        JSR    MPLD      ;LOAD MAP
   21307  34647        LDA    3,LAST
   21310  30644        LDA    2,C2
   21311  50644        STA    2,FIRST   ;PROTECT LOC 0
   21312 102040        ADCO   0,0                                        (9)
   21313   2657        JMP    @MRET     ;ACTIVATE MAP ON RETURN

   21314  20652 MPLD: LDA    0,MUSR
   21315  61002        DOA    0,2       ;SELECT USER MAP
   21316  73002        DOC    2,2       ;LOAD FROM TABLE
   21317   1400        JMP    0,3

   21320    571 JJMTB:JMP    JMTBL     ;ELEVATOR TO MTBL (BEGINNING OF MAP TABLE)
   21321    623 JJJPT:JMP    JJJPR     ;ELEVATOR TO PRINT
   21322    670 JPKUP:JMP    PKUP      ;ELEVATOR TO PKUP

   21323    220 TDCMD:220              ;TEST DISK COMMAND
```

```
; DISC CONTROLLER SELFTEST...ISSUE TST TO WD BOARD, CHK STATUS

   21324   4563 DISKT:JSR    JJPK      ;
   21325      0        0              ;
   21326   4624        JSR    JJLIO     ;GET I/O FLAG
   21327 101014        SKZ    0,0       ;SHOULD I/O BE TESTED
   21330    562        JMP    JMOVE     ;NO, JUMP OVER DISK, TAPE, AND SERIAL PORT
                                        ;TESTS
   21331  20772        LDA    0, TDCMD  ;
   21332  61057        DOA    0,57      ;ISSUE TEST COMMAND TO WD BOARD
   21333  64457 DSTAT:DIA    1,57      ;GET DISK STATUS
   21334 125300        MOVS   1,1
   21335 125112        MOVL#  1,1,SZC   ;WAIT FOR NOT BUSY                (10)
   21336    775        JMP    DSTAT
   21337  60451        DIA    0,51      ;READ ERROR REGISTER
   21340 101004        MOV    0,0,SZR   ;ANY ERROR ?
   21341  63077        HALT   ; YES, FAILED... A0= ERROR STATUS
   21342   4602        JSR    JJJPR     ; NO, CONTINUE
   21343  20040        .TXT   "<40><40>
   21344  42111 DI
   21345  51513 SK
   21346  20114  L
   21347  47507 OG
   21350  44503 IC
   21351  20117  O
   21352  45454 K,
   21353      0 "
```

```
; TAPE TEST: SWITCHES TAPE INTO TEST MODE, THEN WRITES OUT ALL BYTES FROM
; 0 THROUGH 377 INCLUSIVE, CHECKING THAT EACH BYTE IS CORRECTLY STORED AND
; RETREIVED FROM THE ON-BOARD TAPE LOOPBACK HARDWARE.

   21354   4533 TAPET:JSR    JJPK      ;
   21355      0        0              ;                                  (11)
   21356  20520        LDA    0,PDATA   ;
   21357  30523        LDA    2,LPAT    ;
   21360  61072        DOA    0,72      ;SWITCH ON TAPE TEST MODE
```

```
---
   21361  61062        DOA    0,62      ;OUTPUT DATA PATTERN TO TAPE LOOPBACK
                                         ;REGISTER
   21362  71000        DOA    2,0       ;SET DATA BUS TO 377
   21363  64461        DIA    1,61      ;READ DATA FROM TAPE LOOPBACK REGISTER
   21364 106414        SEQ    0,1       ;TEST DATA READ BACK O.K.?
   21365  63077        HALT             ;NO, FAILED! A0=SHOULD BE, A1=IS
   21366 112415        SNE    0,2       ;YES, DONE ALL PATTERNS?
   21367    403        JMP    TPASS     ;YES, EXIT TAPE TEST
   21370 101400        INC    0,0       ;NO, INCREMENT A0 ...                    (11)
   21371    766        JMP    TAPET+3   ;      ... AND CONTINUE TEST WITH NEXT
                                         ;PATTERN
   21372  61073 TPASS:DOA    0,73      ;SWITCH OFF TAPE TEST MODE
   21373   4726        JSR    JJJPT     ;
   21374  20040        .TXT   "
   21375  52101 TA
   21376  50105 PE
   21377  20114  L
   21400  47507 OG
   21401  44503 IC
   21402  20117  O
   21403  45454 K,
   21404      0 "
```

```
; ASYNCHRONOUS SERIAL PORT TEST

; FIRST, DETERMINE THE NUMBER OF AVAILABLE ASYNCHRONOUS SERIAL
; PORT BOARDS.  THEN TEST EACH PORT ON EACH BOARD AS FOLLOWS:

; TURN ON THE SERIAL PORT DIAGNOSTIC LOOPBACK FEATURE AND WRITE
; OUT ALL BYTES FROM 0 THROUGH 377 INCLUSIVE TO EACH PORT IN
; TURN, CHECKING THAT EACH BYTE IS CORRECTLY RECEIVED VIA THE
; ON-BOARD LOOPBACK HARDWARE.

   21405   4605 MUXT: JSR    PKUP      ;SAVE ADDRESS OF LAST TEST STARTED AT
                                         ;MEMORY LOCATION 2
   21406  63077        HALT             ;
                                         ;ISSUE PORT RESET COMMAND TO ALL
                                         ;PORTS
   21407  20471        LDA    0,PRST    ;A0=RESET PORT CONTROL WORD
   21410  24462        LDA    1,CMDO    ;A1=DOA 0,12 INSTRUCTION (WRITE PORT     (12)
                                         ;COMMAND REGISTER)
   21411  30472        LDA    2,MNPTS   ;A2=HIGHEST PORT NUMBER (TWOS
                                         ;COMPLEMENTED)
                                         ;NOTE THAT THIS IS INITIALLY SET TO -17
                                         ;(16 PORTS) BEFORE ACTUALLY PERFORMING THE
                                         ;PORT SIZING ROUTINE.
   21412   4525        JSR    CMND      ;EXECUTE RESET
                                         ;NOW, ISSUE PORT PARAMETERS (8 DATA BITS,
                                         ;EVEN PARITY, 1 STOP BIT)
   21413  20466        LDA    0,PCON    ;A0=INITIALIZE CONTROL WORD
   21414  24456        LDA    1,CMDO    ;A1=DOA 0,12 INSTRUCTION
   21415  30466        LDA    2,MNPTS   ;A2=-17 (-15 DECEMAL)
   21416   4521        JSR    CMND      ;EXECUTE PORT INITIALIZATION
   21417  61070        DOA    0,70      ;SWITCH ON SERIAL PORT LOOPBACK TEST
                                         ;MODE.  EACH PORT WILL NOW BE CAPABLE OF
                                         ;READING BACK ANY DATA SENT OUT.
   21420  20466        LDA    0,FLG3    ;FIRST PASS OF SELFTEST?
   21421 101014        SKZ    0,0       ;
```

```
---
   21422    471        JMP    WDATA    ;NO, SKIP PORT SIZING ROUTINE
                                        ;YES, THEN ...

; DETERMINE THE NUMBER OF AVAILABLE ASYNCHRONOUS SERIAL PORTS BY
; PERFORMING CURSORY TESTING ON EACH PORT, STARTING WITH PORT
; 16 (DECIMAL), AND WORKING DOWNWARD.  IF THE NUMBER DETERMINED
; IN THIS MANNER IS NOT 4, 8, 12, OR 16 (DECIMAL) THEN A SERIAL
; PORT BOARD HOLDS A NONFUNCTIONAL PORT AND, AS A RESULT,
; SELFTEST WILL HALT.

   21423  34454 SIZEP:LDA    3,RMASK  ;A3=1.  READ STATUS REGISTER MASK.  USED
                                        ;TO MASK OFF ALL STATUS BITS EXCEPT THE
                                        ;RECEIVE REGISTER FULL BIT
   21424  20461 .SIZ1:LDA    0,C125   ;A0=125
   21425 152400       SUB    2,2      ;CLEAR ACCUMULATOR 2
   21426  50456       STA    2,WAIT   ;CLEAR WAIT
   21427  61047 WDAT: DOA    0,47     ;OUTPUT TEST DATA TO SERIAL PORT
                                        ;(INITIALLY PORT 16, BUT GETS DECREMENTED
                                        ;EACH PASS)
   21430  64446 RDSTS:DIA    1,46     ;A1=CONTENTS OF THE RECEIVER STATUS
                                        ;REGISTER (INITIALL PORT 16)
   21431 137414       AND#   1,3,SZR  ;IS THE RECEIVE DATA REGISTER FULL?
   21432    414       JMP    RDAT     ;YES, READ THE RECEIVE DATA REGISTER
   21433  10451       ISZ    WAIT     ;NO, INCREMENT THE WAIT COUNTER.  HAS IT
                                        ;BEEN BUMPED 64K TIMES?
   21434    774       JMP    RDSTS    ;NO, AGAIN CHECK THE SERIAL PORT STATUS
                                        ;REGISTER
                                        ;YES, THIS PORT IS EITHER NONEXISTENT OR
                                        ;MALFUNCTIONING.  THEREFORE, DECREMENT
                                        ;ALL I/O INSTRUCTIONS TO THE NEXT LOWER
                                        ;PORT

   21435  14772 .SIZ2:DSZ    WDAT     ;\ DECREMENT THE WRITE DATA INSTRUCTION
   21436  14771       DSZ    WDAT     ;/
   21437  14771       DSZ    RDSTS    ;\ DECREMENT THE READ STATUS INSTRUCTION
   21440  14770       DSZ    RDSTS    ;/
   21441  14405       DSZ    RDAT     ;\ DECREMENT THE READ DATA INSTRUCTION
   21442  14404       DSZ    RDAT     ;/
   21443  10440       ISZ    MNPTS    ;DECREMENT THE HIGHEST PORT NUMBER BY ONE.
                                        ;IF DECREMENTED TO ZERO THEN HALT.
   21444    760       JMP    .SIZ1    ;TEST NEXT ASYNCHRONOUS SERIAL PORT
   21445  63077       HALT            ;

   21446  64447 RDAT: DIA    1,47     ;A1=THE CONTENTS OF THE RECEIVE DATA
                                        ;REGISTER
   21447 106414       SEQ    0,1      ;WRITE=READ?
   21450    765       JMP    .SIZ2    ;NO, THIS PORT IS EITHER NONEXISTENT OR
                                        ;MALFUNCTIONING.  TEST THE NEXT LOWER
                                        ;PORT.
   21451  30432       LDA    2,MNPTS  ;YES, TRANSFER THE CURRENT PORT NUMBER TO
                                        ;ACCUMULATOR 2
   21452 150400       NEG    2,2      ;NEGATE THE CONTENTS OF ACCUMULATOR 2 TO
                                        ;OBTAIN A POSITIVE NUMBER
   21453 151622       INCZR  2,2,SZC  ;IS A2=4, 10, 14, OR 20 (4, 8, 12, 16)?
                                        ;TEST BY DIVIDING ACCUMULATOR 2 BY 4 IN
                                        ;TWO SEPERATE STEPS.
   21454  63077       HALT            ;NO, ACCUMULATOR 2 IS NOT DIVISIBLE BY 2
   21455 151202       MOVR   2,2,SZC  ;YES, DIVISIBLE BY 2, DIVIDE AGAIN BY 2.
   21456  63077       HALT            ;NO, ACCUMULATOR 2 IS NOT DIVISIBLE BY 4
```

(12)

```
---
21457   4405        JSR    .SIZ3     ;YES, A2 IS DIVISIABLE BY 4 AND NOW
                                     ;CONTAINS 1, 2, 3, OR 4.  NOW MODIFIY
                                     ;THE NUMBER OF SERIAL PORTS AVAILABLE
                                     ;MESSAGE TEXT.  PERFORM A JSR TO LOAD
                                     ;ACCUMULATOR 3 WITH THE START OF THE
                                     ;MESSAGE TEXT TABLE.
21460  20064        20064            ;<40><64>  4  PORTS
21461  20070        20070            ;<40><70>  8  PORTS
21462  30462        30462            ;<61><62>  12 PORTS
21463  30466        30466            ;<61><66>  16 PORTS
21464 157000 .SIZ3:ADD    2,3       ;CALCULATE THE ADDRESS OF THE CORRECT
                                     ;NUMBER OF PORTS TEXT FROM THE TABLE ABOVE
21465  31777        LDA    2,-1,3    ;A2=NUMBER OF SERIAL PORTS TEST
21466  50501        STA    2,POKMG+1;MODIFY "PORTS OK" MESSAGE
21467 176000        ADC    3,3       ;A3=177777
21470  54416        STA    3,FLG3    ;TRANSFER ACCUMULATOR 3 TO THE PORT SIZING
                                     ;COMPLETED FLAG
21471    422        JMP    WDATA     ;EXIT TO TEST ALL AVAILABLE SERIAL PORTS

21472  61012 CMDO: DOA    0,12      ;INITIAL VALUE OF COMMAND OUT INSTRUCTION
21473  61013 DATO: DOA    0,13      ;INITIAL VALUE OF DATA OUT INSTRUCTION
21474  64412 STATI:DIA    1,12      ;INITIAL VALUE OF STATUS IN INSTRUCTION
21475  64413 DATI: DIA    1,13      ;INITIAL VALUE OF DATA IN INSTRUCTION
21476      0 PDATA:0                ;DATA TO BE OUTPUT
21477      1 RMASK:1                ;INPUT STATUS MASK (RECEIVER FULL)
21500      3 PRST: 3                ;PORT CONTROL WORD (RESET)
21501     31 PCON: 31               ;PORT CONTROL WORD (8 BIT, EVEN PARITY, 1
                                     ;STOP)
21502    377 LPAT: 377              ;LAST DATA PATTERN                    (12)
21503 177761 MNPTS:-17             ;COMPLEMENT OF THE MAXIMUM PORT NUMBER
21504      0 WAIT: 0                ;
21505    125 C125: 125              ;125 OCTAL
21506      0 FLG3: 0                ;PORT SIZING COMPLETED FLAG

21507    613 JJPK: JMP    JPKUP     ;ELEVATOR TO PKUP
21510    611 JJJJP:JMP    JJJPT     ;ELEVATOR TO PRINT
21511    520 JMTBL:JMP    MTBL      ;ELEVATOR TO MTBL (BEGINNING OF MAP TABLE)
21512    464 JMOVE:JMP    MOVE      ;ELEVATOR TO MOVE

21513  20763 WDATA:LDA   0,PDATA   ;
21514  24757       LDA    1,DATO
21515  30766       LDA    2,MNPTS
21516   4421       JSR    CMND      ;
21517  24756 TEST: LDA    1,DATI
21520  44426       STA    1,RDATA
21521  24753       LDA    1,STATI
21522  44405       STA    1,RSTAT
21523  30760       LDA    2,MNPTS
21524  34753       LDA    3,RMASK
21525 126400       SUB    1,1
21526  44756       STA    1,WAIT
21527  64412 RSTAT:DIA    1,12      ;***** GETS MODIFIED BY PROGRAM *****
21530 137415       AND#   1,3,SNR
21531    402       JMP    .WAIT
21532    414       JMP    RDATA

21533  10751 .WAIT:ISZ    WAIT      ;TIMED OUT ?
21534    773       JMP    RSTAT     ; NO, CONTINUE
21535  61071       DOA    0,71      ;SWITCH OFF MUX TEST MODE
```

```
---
   21536  63077        HALT    ; YES, TIMED OUT !

   21537  44401 CMND:  STA     1,CMND+1 ;A0=COMMAND, A1= INSTRUCTION, A2=MINUS
                                        ;NUMBER OF PORTS
   21540  61012        DOA     0,12     ;***** GETS MODIFIED BY PROGRAM *****
   21541  10777        ISZ     CMND+1   ;MODIFY INSTRUCTION
   21542  10776        ISZ     CMND+1   ;TO ADDRESS NEXT PORT
   21543 151404        INC     2,2,SZR  ;FINISHED ALL PORTS ?
   21544    774        JMP     CMND+1   ;NO ,CONTINUE
   21545   1400        JMP     0,3      ; YES, RETURN

   21546  64413 RDATA:DIA     1,13     ;***** GETS MODIFIED BY PROGRAM *****
   21547 106414        SEQ     0,1      ;CHECK LOOPBACK DATA
   21550  63077        HALT    ;FAILED ! A0 = SHOULD BE, A1 = IS
   21551  10756        ISZ     RSTAT    ;MODIFY INSTRUCTION ...                  (12)
   21552  10755        ISZ     RSTAT    ; ... TO ADDRESS NEXT PORT
   21553  10773        ISZ     RDATA    ;MODIFY INSTRUCTION ...
   21554  10772        ISZ     RDATA    ; ... TO ADDRESS NEXT PORT
   21555 151404        INC     2,2,SZR  ;DONE ALL PORTS ?
   21556    751        JMP     RSTAT    ; NO, TEST NEXT PORT
   21557  24723        LDA     1,LPAT   ; YES, MOVE ON TO NEXT DATA PATTERN
   21560 106415        SNE     0,1      ;DONE 0 THROUGH 377 PATTERNS ?
   21561    403        JMP     MXEND    ; YES, EXIT
   21562 101400        INC     0,0      ; NO, INCREMENT (A0) TO NEXT PATTERN ...
   21563    731        JMP     WDATA+1  ; ... AND CONTINUE
   21564  61071 MXEND:DOA     0,71     ;SWITCH OFF MUX TEST

   21565   4723        JSR     JJJJP    ;
   21566  20040 POKMG:.TXT    "<40><40>
   21567  20040 <40><40>
   21570  20120 <40>P
   21571  47522 OR
   21572  52123 TS
   21573  20117  O
   21574  45456 K.
   21575      0 "
```

```
;MOVE SELFTEST THROUGH CORE AND REPEAT

   21576   4711 MOVE:  JSR     JJPK     ;
   21577 130406        -DIST*2          ;TENT. ASSUME DOUBLE MOVE REQUIRED
   21600  20425        LDA     0,R.MIN
   21601  24425        LDA     1,R.MAX
   21602 162433        SLE     3,0      ;IS SELF WHERE SINGLE MOVE WOULD
   21603 166033        SLS     3,1      ;    CAUSE STRADDLING WORDS 0-3 ?
   21604 151240        MOVOR   2,2      ;  NO, THEN DO SINGLE MOVE               (13)
   21605  21602        LDA     0,TOPWD-REF2,3
   21606  24421        LDA     1,R.OFS
   21607 136400        SUB     1,3      ;A3 = CURRENT LOC. OF SELF
   21610 173000        ADD     3,2
   21611 113400        AND     0,2      ;A2 = NEW LOCATION OF SELF
   21612  24416        LDA     1,NWRDS  ;
   21613  21400 MOVLP:LDA     0,0,3    ;NOW DO THE MOVE LOOP
   21614  41000        STA     0,0,2
   21615 175400        INC     3,3
   21616 151400        INC     2,2
```

```
---
   21617 125404        INC     1,1,SZR  ;MOVE DONE ?
   21620    773        JMP     MOVLP    ;  NO
   21621  24407        LDA     1,NWRDS  ;
   21622 133000        ADD     1,2
   21623  50000        STA     2,0      ;FOR EASILY FINDING SELF WHEN MOVED
   21624   1000        JMP     0,2

   21625  22757 R.MIN: DIST-END-200+REF2-1;                                    (13)
   21626  25016 R.MAX: DIST+REF2-L.SELF+4;
   21627   1215 R.OFS: REF2-L.SELF     ;
   21630 175746 NWRDS:L.SELF-END-200   ;

   21631   5400 MTBL: JSR     0,3      ;PICKUP LAST ADDRESS + 1 (BEGIN MEMORY
                                       ;MAP TABLE)

          23575 DIST=23575
          21632 END=.

                      .EOT             ;SELFTEST
```

1.6 MARK 4 SELF-TEST LISTING

The individual tests on the following MARK 4 CPU Self-Test listing are numbered to correlate with the test descriptions given in Section 1.4.

MARK 4 SELF-TEST LISTING (1 of 21)

```
ASM ,@MK4.SELF.LST,MK4.SELF.TXT
NOV 23, 1987  14:41:15
; MARK 4 SELF TEST
; MAY 22, 1986
; COPYRIGHT (C) 1986, POINT 4 DATA CORP.

             1        .TXTM  1
         77600        SELF=77600
         77600        .LOC   SELF

   77600    403        JMP    .+3
   77601 102000        ADC    0,0        ;ENTRY FOR AUTO IPL
   77602  40536        STA    0,IPLF     ;RUN SELF ONCE, THEN BOOT FROM DISC

; TEST UNCONDITIONAL SKIP CAPABILITY

   77603 101020        MOVZ   0,0        ;TEST NON-SKIP
   77604 101021        MOVZ   0,0,SKP    ;TEST UNCONDITIONAL SKIP (WITH C = ZERO)
   77605  63077        HALT

   77606 125040        MOVO   1,1
   77607 125041        MOVO   1,1,SKP    ;UNCONDITIONAL SKIP (WITH C = 1)
   77610  63077        HALT

   77611 152400        SUB    2,2
   77612 152401        SUB    2,2,SKP    ;UNCONDITIONAL SKIP (WITH ZERO RESULT)
   77613  63077        HALT                                                    (1)

   77614 176000        ADC    3,3
   77615 176001        ADC    3,3,SKP    ;UNCONDITIONAL SKIP (WITH NON-ZERO RESULT)
   77616  63077        HALT

; TEST SKIP USING CARRY CONDITION

   77617 101042        MOVO   0,0,SZC
   77620 101062        MOVC   0,0,SZC    ;SKIP ON ZERO CARRY
   77621  63077        HALT

   77622 101023        MOVZ   0,0,SNC
   77623 101063        MOVC   0,0,SNC    ;SKIP ON NON-ZERO CARRY
   77624  63077        HALT

; TEST SKIP USING (ZERO OR NON-ZERO) RESULT CONDITION

   77625 102004        ADC    0,0,SZR
   77626 102404        SUB    0,0,SZR    ;SKIP ON ZERO RESULT, USING A0
   77627  63077        HALT

   77630 126405        SUB    1,1,SNR
   77631 125405        INC    1,1,SNR    ;SKIP ON NON-ZERO RESULT, USING A1
   77632  63077        HALT

   77633 152004        ADC    2,2,SZR
   77634 150004        COM    2,2,SZR    ;SKIP ON ZERO RESULT, USING A2
   77635  63077        HALT

   77636 176004        ADC    3,3,SZR
   77637 175404        INC    3,3,SZR    ;SKIP ON ZERO RESULT, USING A3
   77640  63077        HALT
```

```
- PAGE 2 -

; TEST COMBINED SKIP CONDITION (BOTH NON-ZERO OR EITHER ZERO)

   77641 126027       ADCZ   1,1,SBN  ;RESULT = NON-ZERO, BUT C = ZERO
   77642 126407       SUB    1,1,SBN  ;RESULT = ZERO, BUT C = NON-ZERO
   77643 126007       ADC    1,1,SBN  ;RESULT AND CARRY BOTH NON-ZERO
   77644  63077       HALT

   77645 152040       ADCO   2,2      ;RESULT = NON-ZERO, CARRY = NON-ZERO
   77646 152410       SUB#   2,2      ;SHOULD NOT CHANGE RESULT (BECAUSE #)
   77647 151030       MOVZ#  2,2      ;SHOULD NOT CHANGE CARRY (BECAUSE #)
   77650 151006       MOV    2,2,SEZ  ;SKIP IF EITHER ZERO
   77651    402       JMP    .+2      ;JUMP OVER HALT IF NO SKIP
   77652  63077       HALT


; TEST SOME LOAD AND ALU INSTRUCTIONS

   77653  20450       LDA    0,C0     ;LOAD A0 = 0
   77654 126400       SUB    1,1      ;SET A1 = 0
   77655 106414       SEQ    0,1
   77656  63077       HALT

   77657  30443       LDA    2,C1     ;LOAD A2 = 1
   77660 176520       SUBZL  3,3      ;SET A3 = 1
   77661 156414       SEQ    2,3
   77662  63077       HALT

   77663  20441       LDA    0,CM1    ;LOAD A0 = 177777 (-1)
   77664 152000       ADC    2,2      ;SET A2 = 177777 (-1)
   77665 112414       SEQ    0,2                                    (1)
   77666  63077       HALT

   77667  24436       LDA    1,CM2    ;LOAD A1 = 177776 (-2)
   77670 176120       ADCZL  3,3      ;SET A3 = 177776 (-2)
   77671 136414       SEQ    1,3
   77672  63077       HALT

   77673  34433       LDA    3,C100K  ;LOAD A3 = 100000
   77674 102620       SUBZR  0,0      ;SET A0 = 100000
   77675 162414       SEQ    3,0
   77676  63077       HALT

   77677  30430       LDA    2,M100K  ;LOAD A2 = 77777
   77700 126220       ADCZR  1,1      ;SET A1 = 77777
   77701 146414       SEQ    2,1
   77702  63077       HALT
```

```
- PAGE 3 -

77703 102120        ADCZL  0,0       ;A0 = 177776, C = 1
77704 101112        MOVL#  0,0,SZC   ;TEST MSB: SHOULD BE = 1
77705 101212        MOVR#  0,0,SZC   ;TEST LSB: SHOULD BE = 0
77706  63077        HALT
77707 101302        MOVS   0,0,SZC   ;TEST C = 1: SWAP SHOULD NOT AFFECT CARRY
77710 101362        MOVCS  0,0,SZC   ;COMPLEMENT CARRY, NOW TEST C = 0
77711  63077        HALT


77712 126520        SUBZL  1,1       ;A1 = 1, C = 0
77713 125113        MOVL#  1,1,SNC   ;TEST MSB: SHOULD BE = 0
77714 125213        MOVR#  1,1,SNC   ;TEST LSB: SHOULD BE = 1
77715  63077        HALT
77716 125303        MOVS   1,1,SNC   ;TEST C = 0: SWAP SHOULD NOT AFFECT CARRY
77717 125363        MOVCS  1,1,SNC   ;COMPLEMENT CARRY, NOW TEST C = 1
77720  63077        HALT
77721    420        JMP    TSWAP


77722      1 C1:    1
77723      0 C0:    0
77724 177777 CM1:   -1
77725 177776 CM2:   -2
77726 100000 C100K:100000
77727  77777 M100K:77777
77730 100000 B0:    100000
77731  40000 B1:    40000
77732  20000 B2:    20000
77733  10000 B3:    10000
77734   4000 B4:    4000
77735   2000 B5:    2000
77736   1000 B6:    1000
77737    400 B7:    400
77740      0 IPLF:  0
```

(1)

```
- PAGE 4 -
; TEST EACH SWAP INPUT TO SHIFTER

   77741  20767 TSWAP:LDA    0,B0
   77742 105300       MOVS   0,1
   77743 131300       MOVS   1,2
   77744 106414       SEQ    0,1
   77745 112414       SEQ    0,2
   77746  63077       HALT

   77747  24762       LDA    1,B1
   77750 135300       MOVS   1,3
   77751 161300       MOVS   3,0
   77752 136414       SEQ    1,3
   77753 122414       SEQ    1,0
   77754  63077       HALT

   77755  30755       LDA    2,B2
   77756 141300       MOVS   2,0
   77757 115300       MOVS   0,3
   77760 142414       SEQ    2,0
   77761 156414       SEQ    2,3
   77762  63077       HALT

   77763  34750       LDA    3,B3
   77764 171300       MOVS   3,2
   77765 145300       MOVS   2,1
   77766 172414       SEQ    3,2
   77767 166414       SEQ    3,1                                    (1)
   77770  63077       HALT

   77771  20743       LDA    0,B4
   77772 111300       MOVS   0,2
   77773 155300       MOVS   2,3
   77774 112414       SEQ    0,2
   77775 116414       SEQ    0,3
   77776  63077       HALT

   77777  24736       LDA    1,B5
  100000 121300       MOVS   1,0
  100001 111300       MOVS   0,2
  100002 122414       SEQ    1,0
  100003 132414       SEQ    1,2
  100004  63077       HALT

  100005  30731       LDA    2,B6
  100006 155300       MOVS   2,3
  100007 165300       MOVS   3,1
  100010 156414       SEQ    2,3
  100011 146414       SEQ    2,1
  100012  63077       HALT

  100013  34724       LDA    3,B7
  100014 165300       MOVS   3,1
  100015 121300       MOVS   1,0
  100016 166414       SEQ    3,1
  100017 162414       SEQ    3,0
  100020  63077       HALT
```

```
- PAGE 5 -
; A FEW MORE BASIC ALU TESTS

100021 102001STALU:ADC    0,0,SKP  ;A0 = 177777
100022  63077      HALT             ;UNCONDITIONAL "SKP" FAILED TO SKIP
100023 126424      SUBZ   1,1,SZR  ;A1=0
100024  63077      HALT
100025 152000      ADC    2,2
100026 151404      INC    2,2,SZR  ;A2=0
100027  63077      HALT
100030 176000      ADC    3,3
100031 162415      SNE    3,0      ;A3,A0 SHOULD = 177777
100032 132414      SEQ    1,2      ;A1,A2 SHOULD = 0
100033  63077      HALT

; A FEW BASIC JMP, LDA, STA, ISZ TESTS USING RELATIVE ADDRESSING

100034  20405      LDA    0,.+5
100035 116414      SEQ    0,3
100036  63077      HALT             ;A0 & A3 SHOULD = 177777
100037  30667      LDA    2,C100K
100040 102621      SUBZR  0,0,SKP
100041 177777      177777
100042 112414      SEQ    0,2
100043  63077      HALT             ;A0 & A2 SHOULD = 100000
100044    402      JMP    .+2       ;TEST JMP REL.
100045  63077      HALT             ;SHOULD JUMP OVER THIS
100046  40401      STA    0,.+1
100047  63077COM00:HALT             ;PGM CHANGES TO 100000=COM 0,0
100050 112415      SNE    0,2                                        (2)
100051  63077      HALT             ;A0 SHOULD = 77777, A2 = 100000
100052 100000      COM    0,0
100053  24774      LDA    1,COM00
100054 112415      SNE    0,2
100055 132414      SEQ    1,2
100056  63077      HALT             ;A0, A1, A2 SHOULD = 100000
100057   4403      JSR    JMP3      ;TEST INSTRS. USED IN "TYPE" S\R
100060  63077HLT1: 63077
100061  77077HLT2: 77077
100062  54002JMP3: STA    3,2       ;LOC. 2 --> LAST TEST BEGUN
100063  25400      LDA    1,0,3
100064  20774      LDA    0,HLT1
100065 106414      SEQ    0,1
100066  63077      HALT             ;A0 & A1 SHOULD = 63077 = (HLT1)
100067 175420      INCZ   3,3
100070  25400      LDA    1,0,3
100071  20770      LDA    0,HLT2
100072 106414      SEQ    0,1
100073  63077      HALT             ;A0 & A1 SHOULD = 77077 = (HLT2)
100074    404      JMP    TISZ

100075      1CNTR: 1

100076  20642LPLF: LDA    0,IPLF
100077   1400      JMP    0,3
```

```
100100 102400TISZ: SUB    0,0
100101  40774      STA    0,CNTR
100102  10773      ISZ    CNTR      ;TEST ISZ AND DSZ INSTR'S
100103  14772      DSZ    CNTR
100104  63077      HALT
100105  14770      DSZ    CNTR
100106  10767      ISZ    CNTR
100107  63077      HALT
```

(2)

```
; ALU TEST: CALCULATE CHECKSUM IN A3 BASED UPON EXECUTION OF ALL
; POSSIBLE ALU INSTRUCTIONS, THEN COMPARE WITH CANNED VALUE (X)

100110 102020TALU: ADCZ   0,0       ;GENERATE 177777
100111  41400      STA    0,+0,3    ;STORE 177777 AT TPWD
100112 177240      ADDOR  3,3       ;COMPLEMENT MSB
100113 102220      ADCZR  0,0       ;GENERATE 77777
100114  41400      STA    0,+0,3    ;STORE 77777 ... AT TPWD IF 32KW
                                     ;             ... AT (TPWD + 100000) .. OR,
                                     ;             ... (TPWD - 100000) IF 64KW
100115   4452      JSR    PIKUP     ;(SKIPS NEXT WORD)
                   ;
100116  42263X:    42263  ;CHECKSUM FOR "EXHAUSTIVE ALU TEST"
```

(3)

```
; EXHAUSTIVE TEST OF ALL ALU INSTRUCTIONS

100117 176220      ADCZR  3,3       ;A3 = 77777 (ARBITRARY INITIAL COND. )
100120 171300      MOVS   3,2       ;A2 = 177577
100121 145520      INCZL  2,1       ;A2 = 177401
100122 102620      SUBZR  0,0       ;A0 = 100000
100123  40401      STA    0,.+1

100124  63077ALUI: HALT             ;CYCLES THROUGH ALL ALU INSTR.
100125 147100      ADDL   2,1       ; \
100126 123100      ADDL   1,0       ;  } FOLD RESULT INTO A3
100127 117100      ADDL   0,3       ; /
100130  10774      ISZ    ALUI      ;MODIFY INSTRUCTION; ALL DONE ?
100131    773      JMP    ALUI      ;  NO, CONTINUE
100132  20764      LDA    0,X       ;  YES
100133 162414      SEQ    3,0       ;IS FINAL RESULT CORRECT ?
100134  63077      HALT             ;  NO, ALU ERROR
```

(4)

```
; BASE 3 ADDRESSING VS. PAGE ZERO

100135   4432      JSR    PIKUP
100136    772      REF1-SELF+400
100137 172032      SGE    3,2       ;IS SELF ABOVE PAGE ZERO ?
100140    432      JMP    TJSR      ;  NO, SKIP PZ TEST
100141 176520      SUBZL  3,3       ;SET UP FOR PAGE ZERO TEST
100142  20002      LDA    0,2
100143  20777      LDA    0,.-1
100144  40403      STA    0,LDA0
100145 175400B3LP: INC    3,3       ;  INCREMENT BY 1 WORD
100146  55400      STA    3,0,3     ;INTO EACH WORD WRITE ITS OWN ADDRESS
```

(5)

```
   100147  20002LDA0: LDA    0,2       ;*******GETS MODIFIED BY PROGRAM******
   100150 116414      SEQ    0,3       ;DID WE GET BACK WHAT WE WROTE?
   100151  63077      HALT              ;  NO
   100152  10775      ISZ    LDA0      ;MODIFY THE LOAD INSTRUCTION
   100153  20410      LDA    0,K377
   100154 162032      SGE    3,0       ;IS A3 < 377
   100155    770      JMP    B3LP      ;  NO, REPEAT LOOP
   100156    414      JMP    TJSR      ;YES, GO ON TO NEXT TEST
   100157   4731JTALU:JSR    TALU                                          (5)
   100160  77777TPWD: 77777
   100161    125K125: 125
   100162      0FLG1: 0
   100163    377K377: 377
   100164 177600CM200:-200
   100165 100013ADR:  LDREL-200        ;USED IN RELATIVE ADDRESSING TEST
   100166    710JPLF: JMP    LPLF

; SUB-ROUTINE TO PICK UP POINTER TO CENTRAL REFERENCE POINT

   100167  54002PIKUP:STA    3,2       ;LOC. 2 --> LAST TEST STARTED
   100170  31400      LDA    2,0,3     ;LOAD PARAMETER WORD
   100171   5401      JSR    1,3       ;SKIP-RETURN WITH POINTER TO "REF1"
         100172 REF1= .                 ;REFERENCE POINT USED FOR ADDRESSING EXTENSION
```

```
; BASE 2, RELATIVE, AND INDIRECT ADDRESSING - ALL WITHIN +-200 OF HERE

   100172   4775TJSR: JSR    PIKUP
   100173     21      LDREL-REF1
   100174 173000      ADD    3,2       ;CALC. LOC. OF "LDREL"
   100175  20767      LDA    0,CM200
   100176 143040      ADDO   2,0
   100177  40766      STA    0,ADR     ;SET UP "ADR" = LDREL - 200
   100200  35200      LDA    3,-200,2
   100201  20777      LDA    0,.-1     ;PICK UP BASE 2 INSTR.
   100202  34600      LDA    3,.-200
   100203  34777      LDA    3,.-1     ;PICK UP REL. ADDR. INSTR.
   100204  40403SETAD:STA    0,LDAB2   ;SET UP BASE 2 INSTRUCTION
   100205  54406      STA    3,LDREL   ;SET UP REL. ADDR. INSTR.
   100206  24756      LDA    1,CM200
   100207  35200LDAB2:LDA    3,-200,2  ;*** GETS MODIFIED BY PROGRAM ***
   100210  22755      LDA    0,@ADR
   100211 116414      SEQ    0,3       ;A0 = INDIR., A3 = BASE 2 ADDRESSING   (6)
   100212  63077      HALT             ;THEY DON'T MATCH !?
   100213  34600LDREL:LDA    3,.-200   ;*** GETS MODIFIED BY PROGRAM ***
   100214 116414      SEQ    0,3
   100215  63077      HALT
   100216  10747      ISZ    ADR       ;INCREMENT INDIRECT ADDRESS
   100217  10770      ISZ    LDAB2     ;AND BASE 2 LOAD INSTRUCTION,
   100220  10773      ISZ    LDREL     ;AND RELATIVE LOAD INSTRUCTION
   100221 125404      INC    1,1,SZR   ;HAVE WE TESTED 200 LOCATIONS ?
   100222    765      JMP    LDAB2     ;  NOT YET, REPEAT LOOP
   100223  35000      LDA    3,0,2     ;PREPARE FOR 2ND 200 LOCATIONS
   100224  20777      LDA    0,.-1     ;PICK UP BASE 2 INSTR.
   100225  34400      LDA    3,.       ;PICK UP REL. ADDR. INSTR.
   100226 101002      MOV    0,0,SZC   ;HAVE WE DONE 2ND PASS ALREADY ?
   100227    755      JMP    SETAD     ;  NO, DO IT NOW
```

```
; CHECK FOR PIB ON 1ST PASS

100230  20732FRST: LDA    0,FLG1
100231 126400       SUB    1,1
100232 106414       SEQ    0,1       ;FIRST PASS ?
100233    460       JMP    CKPL      ;  NO
100234 102000       ADC    0,0       ;  YES, SET FLAG
100235  40725       STA    0,FLG1
100236  20723IOCK:  LDA    0,K125    ;CHECK IF TAPE IS PRESENT
100237  24724       LDA    1,K377
100240  61072       DOA    0,72      ;TURN ON TAPE LOOPBACK
100241  61062       DOA    0,62      ;SEND BYTE TO TAPE
100242  65000       DOA    1,0       ;CLEAR BUSS
100243  64461       DIA    1,61      ;GET BACK BYTE
100244 106415       SNE    0,1       ;SAME AS SENT ?
100245    403       JMP    TST0      ;  YES, PIB PRESENT
100246 102000       ADC    0,0       ;  NO, NO TAPE
100247  40535       STA    0,FLG2
100250  20711TST0:  LDA    0,K125
100251  61070       DOA    0,70      ;TURN ON LOOPBACK
100252  61013       DOA    0,13      ;SEND CHARACTER
100253 152400       SUB    2,2
100254  50472       STA    2,DLAY+1  ;CLEAR DELAY COUNTER
100255  30470       LDA    2,DLAY    ;DELAY LOOP
100256  10470       ISZ    DLAY+1
100257    777       JMP    .-1
100260 151404       INC    2,2,SZR
100261    775       JMP    .-3
100262  24701       LDA    1,K377
100263  65000       DOA    1,0       ;CLEAR BUSS
100264  64413       DIA    1,13      ;GET BACK CHARACTER
100265  61071       DOA    0,71      ;LOOPBACK OFF
100266 106415       SNE    0,1       ;CHARACTER SAME AS SENT ?
100267    410       JMP    TPM4      ;  YES
100270  20514       LDA    0,FLG2    ;  NO
100271 101014       SKZ    0,0       ;WAS TAPE ALSO BAD ?
100272    402       JMP    SETF      ;  YES, NO PIB
100273  63077       HALT   ;  NO, PORT 1 BAD !
100274 102000SETF:  ADC    0,0       ;NO PIB, THEREFORE ...
100275  40553       STA    0,NIOF    ; ... RUN SELFTEST WITHOUT ...
100276    570       JMP    TMAP      ; ... TYPEOUT OR IO TESTS

100277   4510TPM4:  JSR    TYPE
100300   6412       .TXT   "<15><12>
100301  46501MA
100302  51113RK
100303  20064 4
100304  20123 S
100305  42514EL
100306  43124FT
100307  42523ES
100310  52056T.
100311  27056..
100312      0"
```

⑦

- PAGE 9 -

```
100313   4653CKPL: JSR    JPLF      ;CHK IF AUTO IPL
100314 101213      SKO    0,0       ;AUTO IPL ENTERED ?
100315    406      JMP    CPOK      ;NO
100316  20532      LDA    0,NIOF    ;YES, PIB INSTALLED ?
100317 101014      SKZ    0,0
100320    403      JMP    CPOK      ;NO, CONTINUE SELFTEST
100321  20464      LDA    0,IPLC    ;SKIP MOVE ROUTINE, JMP TO IPL
100322  42464      STA    0,@IPLM                                    (7)
100323  20525CPOK: LDA    0,NIOF
100324 101014      SKZ    0,0
100325    541      JMP    TMAP
100326   4461      JSR    TYPE      ;CPU OK
100327   6412      .TXT   "<15><12>
100330  41520CP
100331  52440U
100332  47513OK
100333  26000,"

100334    532      JMP    TMAP

100335    632JPKP: JMP    PIKUP
```

- PAGE 10 -

```
; SOME SUBROUTINES USED FOR TYPE AND PORT 0 TEST

100336  20407TYPR: LDA    0,DLAY
100337 101404      INC    0,0,SZR
100340    777      JMP    .-1
100341  10405      ISZ    DLAY+1
100342    774      JMP    TYPR
100343  61071      DOA    0,71
100344   1400      JMP    0,3

100345 177774DLAY: -4
100346      0      0
100347      0CSAV: 0

100350 151100TIMO: MOVL   2,2
100351  50776      STA    2,CSAV
100352  30773      LDA    2,DLAY                                     (MISC)
100353 151404      INC    2,2,SZR
100354    777      JMP    .-1
100355  10771      ISZ    DLAY+1
100356    402      JMP    .+2
100357  63077      HALT
100360 152400      SUB    2,2
100361  50765      STA    2,DLAY+1
100362  30765      LDA    2,CSAV
100363 151200      MOVR   2,2
100364   1400      JMP    0,3
```

```
100365  77600.SELF:SELF
100366 101435END.: END
100367      1TBLT: 1
100370    100K100: 100
100371    200C200: 200
100372   1776C1776:1776
100373    377C377: 377
100374   1400C1400:1400
100375  77400C177L:77400
100376 177700CN100:-100
100377   1000C1K:  1000
100400   2000K2K:  2000
100401    377RVAL: 377
100402   1000MRNT: 1000
100403  77377TEMP3:77377
100404      0FLG2: 0
100405    427IPLC: IPL-MOVE+400
100406 101373IPLM: MOVE
```


; TYPE-OUT SUBROUTINE...ALSO TESTS PORT 0

MISC

```
100407  61070TYPE: DOA    0,70      ;TURN ON MUX LOOPBACK
100410  25400TYP1: LDA    1,0,3     ;GET 2 CHARACTERS
100411 102400      SUB    0,0
100412  40734      STA    0,DLAY+1
100413 175420      INCZ   3,3       ;BUMP CHARACTER POINTER
100414  54767      STA    3,TEMP3   ;SAVE CHARACTER POINTER
100415  20760TYP2: LDA    0,C177L   ;DO LEFT BYTE 1ST
100416 123705      ANDS   1,0,SNR   ;TERMINATOR ?
100417    717      JMP    TYPR      ;  YES, EXIT
100420  70410TYPL: DIA    2,10      ;  NO, GET PORT 0 STATUS
100421 151202      MOVR   2,2,SZC   ;ANYTHING IN REC. REG ?
100422  63077      HALT   ;  YES, ABORT
100423 151212      SKE    2,2       ;XMIT REG FULL ?
100424    404      JMP    OPCHR     ;  NO, XMIT CHARACTER
100425   4723      JSR    TIMO      ;  YES, CHECK TIMEOUT
100426 151100      MOVL   2,2       ;RECONSTITUTE CARRY ...
100427    771      JMP    TYPL      ; ... AND CONTINUE WAIT
100430  61011OPCHR:DOA    0,11      ;OUTPUT CHARACTER
100431 151100      MOVL   2,2       ;RESTORE CARRY
100432 152460      SUBC   2,2
100433  50713      STA    2,DLAY+1  ;RESET DELAY COUNTER
100434  70410RDSTA:DIA    2,10      ;READ PORT 0 STATUS
100435 151212      SKE    2,2       ;RECEIVER EMPTY ?
100436    403      JMP    GCHAR     ;  NO, GO TO GET CHARACTER
100437   4711      JSR    TIMO      ;  YES, CHECK FOR TIMEOUT
100440    774      JMP    RDSTA
100441  70411GCHAR:DIA    2,11      ;GET CHARACTER
100442 112414      SEQ    0,2       ;SAME AS SENT ?
100443  63077      HALT   ;  NO, ERROR ! AC0 = SHOULD BE, AC2 = IS
100444  34737      LDA    3,TEMP3   ;RESTORE CHARACTER POINTER
100445 125362      MOVCS  1,1,SZC   ;  YES, CONTINUE. DONE BOTH ?
100446    747      JMP    TYP2      ;    NO, NEXT CHARACTER
100447    741      JMP    TYP1      ;    YES, NEXT 2 CHARACTERS

100450      0NIOF: 0
```

```
- PAGE 12 -
; TEST MAP RAMS...
; TEST IF OLD OR NEW MAP THEN WRITE ALL VALUES FROM 377
; (OLD) OR 1776 (NEW) THROUGH 1 INTO ALL LOCATIONS OF
; MAP RAMS. READ BACK, AND COMPARE. REPEAT FOR ALL 4 MAPS.

; TEMPORARY STORAGE AND A SUBROUTINE
  100451       0TMFT0:0
  100452       0TMFT1:0

  100453  54777TMSB: STA    3,TMFT1  ;SAVE RETURN
  100454   4572      JSR    JATB     ;A3:END OF PROGRAM+1 (START OF TBL)
  100455  30723      LDA    2,K2K    ;A2:2000
  100456  24720      LDA    1,CN100  ;A1:-100 TO FILL 64 WORDS
  100457  41400TMS1: STA    0,0,3    ;FILL THE TABLE
  100460 175400      INC    3,3      ;BUMP POINTER
  100461 143000      ADD    2,0      ;ADJUST TO NEXT PAGE
  100462 125404      INC    1,1,SZR  ;TEST FOR DONE
  100463    774      JMP    TMS1     ;NOT YET
  100464  34766      LDA    3,TMFT1  ;RETURN
  100465   1400      JMP    0,3      ;WITHOUT INDIRECT


  100466   4647TMAP: JSR    JPKP     ;(2):NXT ADDRESS A2:(NXT ADDRESS)
  100467      0      0
  100470  71002      DOA    2,2      ;INITIALIZE TO PMAP A
  100471  50711      STA    2,MRNT   ;MRNT:0
  100472  20700      LDA    0,C1776  ;A0:1776 TO ASSUME NEW MAP
  100473   4760      JSR    TMSB     ;FILL TABLE
  100474   4552      JSR    JATB     ;POINT TO TABLE                    (8)
  100475  77002      DOC    3,2      ;LDMP FROM TABLE
  100476  76402      DIC    3,2      ;RDMP TO TABLE
  100477  25400      LDA    1,0,3    ;A1:FIRST TABLE ENTRY
  100500  20672      LDA    0,C1776  ;ASSUME NEW MAP
  100501  30673      LDA    2,C1400  ;CONSTANT TO TEST NEW MAP
  100502 147405      AND    2,1,SNR  ;MUST BE NEW MAP
  100503  20670      LDA    0,C377   ;ELSE IT IS OLD MAP
  100504  40745      STA    0,TMFT0  ;SAVE LAST PHYSICAL PAGE NO.

  100505  20744TMPR: LDA    0,TMFT0  ;LAST PHYSICAL PAGE NO.
  100506  40673      STA    0,RVAL   ;TO RVAL
  100507  20672TMRL: LDA    0,RVAL   ;GET CURRENT VAL TO WRITE
  100510   4743      JSR    TMSB     ;FILL TABLE WITH A0
  100511  20671      LDA    0,MRNT   ;GET MAP TO LOAD
  100512  61002      DOA    0,2      ;SELECT MAP FOR LOAD
  100513   4533      JSR    JATB     ;GET TABLE ADDR
  100514  77002      DOC    3,2      ;LOAD MAP MEM
  100515  30653      LDA    2,K100   ;A2:100
  100516  50651      STA    2,TBLT   ;INITIALIZE FOR 64 WDS
  100517 173000      ADD    3,2      ;A2:TABLE LOCATION FOR MAP READ
  100520  72402      DIC    2,2      ;READ MAP MEM
  100521  25400TCHK: LDA    1,0,3    ;GET CURRENT VALUE FROM TABLE
  100522  21000      LDA    0,0,2    ;GET DATA READ FROM MAP
  100523 106414      SEQ    0,1      ;COMPARE ?
  100524  63077      HALT   ;A0 = IS, A1 = SHOULD BE
  100525 175400      INC    3,3
  100526 151400      INC    2,2
  100527  14640      DSZ    TBLT     ;DONE WITH TABLE ?
  100530    771      JMP    TCHK     ; NO
  100531  14650      DSZ    RVAL     ; YES. DONE ALL VALUES ?
```

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---
   100532    755       JMP    TMRL      ;NO, DO NEXT
   100533  24636       LDA    1,C200    ;YES, DONE ALL 4 MAPS ?
   100534  20646       LDA    0,MRNT
   100535 123000       ADD    1,0
   100536  30641       LDA    2,C1K
   100537 112415       SNE    0,2
   100540    403       JMP    MAPOK     ;DONE ALL 4 MAPS ?
   100541  40641       STA    0,MRNT    ; NO, DO NEXT
   100542    743       JMP    TMPR
   100543  20705MAPOK:LDA    0,NIOF
   100544 101014       SKZ    0,0
   100545    413       JMP    MWDTH
   100546   4641       JSR    TYPE      ;MAP OK
   100547  20040       .TXT   "<40><40>
   100550  46501MA
   100551  50040P
   100552  47513OK
   100553  26000,"

   100554    404       JMP    MWDTH

   100555    632JTYP:  JMP    TYPE
   100556  20672LIOF:  LDA    0,NIOF
   100557   1400       JMP    0,3

   100560  20507MWDTH:LDA    0,MAPN    ;TIME TO TEST MEMORY WIDTH?
   100561 101004       MOV    0,0,SZR
   100562    512       JMP    TMEM-2    ;NO                                    (8)

;TEST MEMORY SIZE OF 128KW,256KW,512KW OR 1MW
   100563   4500TWDTH:JSR    JSTB      ;SETUP MAP TABLE
   100564   4463       JSR    CNGTB     ;CHANGE TABLE LOAD MAP
                                        ;HERE MAP IS ACTIVATED
   100565  20664       LDA    0,TMFT0   ;TEST FOR OLD BOARD
   100566  30503       LDA    2,CMT1    ;177401
   100567 143004       ADD    2,0,SZR   ;(TMFTO)=377?
   100570    406       JMP    TWDN      ;NO, MUST BE NEW MAP
   100571  30501       LDA    2,CMT2    ;A2:173777 OLD MAP
   100572  34501       LDA    3,CMT3    ;A3:4      OLD MAP
   100573  20426       LDA    0,CMT4    ;INDEX TO .5MB
   100574  40426       STA    0,CM4
   100575    403       JMP    TWD0      ;AND CONTINUE

   100576  34470TWDN: LDA    3,C20     ;ASSUME 16 BLKS OF 64KW
   100577  30471       LDA    2,TOPWD   ;A2:177777
   100600 102400TWD0: SUB    0,0       ;A0:TST VALUE
   100601  41000       STA    0,0,2     ;(177777):000000
   100602  25000       LDA    1,0,2     ;A1:(177777)?
   100603 106414       SEQ    0,1       ;WRITE = READ?
   100604    427       JMP    TWD2      ;NO
   100605 100000       COM    0,0       ;COMPL TEST VALUE
   100606  41000       STA    0,0,2     ;(177777):177777
   100607  25000       LDA    1,0,2     ;A1:(177777)?
   100610 106414       SEQ    0,1       ;WRITE = READ?
   100611    422       JMP    TWD2      ;NO
   100612  54577TWD1: STA    3,MVAL    ;MVAL:A3:16,8,4 OR 2
   100613  54454       STA    3,MAPN
   100614   4407       JSR    TWD3      ;PICK UP MESSAGE ADDRESS
   100615  20062       20062            ;<40><62>  2MB
```

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---
   100616  20061      20061           ;<40><61>  1MB
   100617  27065      27065           ;<56><65> .5MB
   100620  27062      27062           ;<56><62> .2MB
   100621 177776CMT4: -2
   100622 177774CM4:  -4
   100623  20777TWD3: LDA    0,CM4     ;GET COUNT -4,-3,-2 OR -1
   100624 117000      ADD    0,3       ;INDEX
   100625  21404      LDA    0,4,3     ;PICK UP MESSAGE
   100626  40552      STA    0,MOKMG+1;AND STORE IT
   100627 102400      SUB    0,0
   100630  61002      DOA    0,2       ;DISABLE MAP STATUS
   100631  62677      IORST            ;MAP OFF
   100632    442      JMP    TMEM-2    ;FINISHED

   100633  20767TWD2: LDA    0,CM4     ;MODIFY MESSAGE INDEX
   100634 101400      INC    0,0
   100635  40765      STA    0,CM4
   100636  20571      LDA    0,M2000   ;A0:-2000
   100637 113000      ADD    0,2       ;DECREMENT LOGICAL ADDRESS
   100640 175220      MOVZR  3,3       ;A3:A3/2
   100641  20427      LDA    0,TOPWD
   100642 163004      ADD    3,0,SZR   ;DONE (A3=1)?
   100643    735      JMP    TWD0      ;NO
   100644 175120      MOVZL  3,3       ;YES FORCE TO BE 2
   100645    745      JMP    TWD1
   100646    544JATB: JMP    JJTB

   100647  54572CNGTB:STA    3,MRET    ;SAVE RETURN
   100650  24752      LDA    1,CM4     ;A1:-4
   100651   4541      JSR    JJTB      ;A3:PROGRAM END + 1
   100652  20553      LDA    0,C100    ;A0:100 (64)
   100653  31474CNGT1:LDA    2,74,3    ;CNG LST 4 ENTRIES TO
   100654 113000      ADD    0,2       ;BE:  0174  128KW
   100655  51474      STA    2,74,3    ;     0275  256KW
   100656 101120      MOVZL  0,0       ;     0476  512KW
   100657 175400      INC    3,3       ;     1077 1024KW
   100660 125404      INC    1,1,SZR
   100661    772      JMP    CNGT1
   100662    536      JMP    CNGXT     ;RETURN VIA @MRET WITH MAP ON

   100663    557JSTB: JMP    STBL
   100664    671JTP2: JMP    JTYP
   100665    671LIO1: JMP    LIOF
   100666     20C20:  20
   100667       0MAPN: 0
   100670 177777TOPWD:177777
   100671 177401CMT1: 177401
   100672 173777CMT2: 173777
   100673      4CMT3: 4
```

(8)

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; MEMORY TEST:  FIRST PASS: SET A BIT TO 1, SET IT TO 0, THEN SET
; IT BACK TO 1, THEN DO THE SAME TO NEXT BIT, ETC.
; SECOND PASS: TEST THAT THE BIT = 1, TOGGLE IT TO 0, RETEST,
; AND BACK TO 1, THEN DO SAME FOR NEXT BIT--
; THUS EACH BIT IS TESTED AFTER ALL OTHER BITS HAVE BEEN TOGGLED.
; THEN REPEAT THE WHOLE TEST WITH 0'S AND 1'S INTERCHANGED
; THIRD TEST: USE EACH WORD'S ADDRESS IN PLACE OF 0'S OR 1'S
; FOURTH TEST: USE 73077 HALT (HAS ODD PARITY) IN PLACE OF ADDRRESS
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(9)

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---
   100674 102400       SUB     0,0
   100675  40533       STA     0,MPNC
   100676   4765TMEM:  JSR     JSTB
   100677   4562       JSR     PKUP
   100700    551       END+200-REF2
   100701 173000       ADD     3,2       ;A2 = FIRST LOC. ABOVE SELF-TEST
   100702  21604       LDA     0,TOPWD-REF2,3
   100703 101220       MOVZR   0,0       ;MIDPOINT OF AVAILABLE RAM
   100704 142033       SLS     2,0       ;ARE WE CURRENTLY ABOVE MIDPOINT ?
   100705   4507       JSR     JSTL      ;YES, TEST LOWER MEMORY
   100706   4507       JSR     JSTH      ;NO, TEST UPPER PORTION
   100707  30515MTEST:LDA     2,FIRST   ;FIRST PASS - SET UP MEMORY
   100710 101003LOOP1:MOV     0,0,SNC   ;IS THIS THE THIRD TEST ?
   100711 141000       MOV     2,0       ;  YES: USE ADDRESS
   100712  41000       STA     0,0,2
   100713 104000       COM     0,1
   100714  45000       STA     1,0,2     ;TOGGLE MEMORY WORD
   100715  41000       STA     0,0,2     ;TOGGLE BACK AGAIN
   100716 151400       INC     2,2
   100717 156032       SGE     2,3       ;ALL SET UP ?
   100720    770       JMP     LOOP1     ;  NOT YET
   100721  30503       LDA     2,FIRST   ;SECOND PASS - TEST MEMORY
   100722 101003LOOP2:MOV     0,0,SNC   ;ARE WE ON THE THIRD TEST ?
   100723 141000       MOV     2,0       ;  YES, USE ADDRESS                    (9)
   100724  25000       LDA     1,0,2
   100725 106414       SEQ     0,1
   100726    511       JMP     MERR      ;ERROR
   100727 104000       COM     0,1
   100730  45000       STA     1,0,2     ;TOGGLE MEMORY
   100731  25000       LDA     1,0,2     ;RETEST
   100732 124000       COM     1,1
   100733 106414       SEQ     0,1
   100734    503       JMP     MERR      ;ERROR
   100735  41000       STA     0,0,2     ;TOGGLE MEMORY WORD BACK AGAIN
   100736 151400       INC     2,2
   100737 156032       SGE     2,3       ;TESTED ALL LOCATIONS ?
   100740    762       JMP     LOOP2     ;  NO
   100741 101466       INCC    0,0,SEZ   ;NOW PREPARE FOR NEXT TEST
   100742  20460       LDA     0,HALTI   ;GET THE HALT INSTRUCTION
   100743  24457       LDA     1,HALTI   ;GET 73077 INSTRUCTION
   100744 122014       ADC#    1,0,SZR   ;HAVE WE DONE FOUR TESTS?
   100745    742       JMP     MTEST     ;NO, DO NEXT TEST
   100746 102400       SUB     0,0
   100747  61002       DOA     0,2       ;DISABLE MAP
   100750  62677       IORST
   100751 102000       ADC     0,0
   100752  40462       STA     0,MTSF

   100753  14714       DSZ     MAPN      ;DONE ALL BLOCKS ?
   100754    402       JMP     .+2       ;NO
   100755    412       JMP     MPFF      ;YES, EXIT
   100756  34447       LDA     3,C100
   100757  24710       LDA     1,MAPN
   100760 124000       COM     1,1
   100761 102400       SUB     0,0
   100762 125405       INC     1,1,SNR
   100763    713       JMP     TMEM      ;TEST NEXT BLK
   100764 163000       ADD     3,0
   100765  40443       STA     0,MPNC
```

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---
   100766    774      JMP    .-4

   100767  20422MPFF: LDA    0,MVAL
   100770  40677      STA    0,MAPN    ;RESTORE BLOCK COUNTER
   100771 102400      SUB    0,0
   100772  40436      STA    0,MPNC    ;RESTORE MPNC:0

   100773   4672MEMOK:JSR    LIOl      ;A0:NIOF
   100774 101014      SKZ    0,0
   100775    422      JMP    JMXT
   100776   4666      JSR    JTP2      ;MEMORY OK
   100777  20040MOKMG:.TXT   "<40><40>
   101000  20040<40><40>
   101001  46502MB
   101002  20115 M
   101003  42515EM
   101004  47522OR
   101005  54440Y
   101006  47513OK
   101007  26000,"

   101010    407      JMP    JMXT

   101011      0MVAL: 0
   101012    556JJTB: JMP    JTBL
   101013    651JTPl: JMP    JTP2
   101014    512JSTL: JMP    STML
   101015    447JSTH: JMP    STMH
   101016    545JMLD: JMP    MPLD
   101017    570JMXT: JMP    MUXT
   101020    533CNGXT:JMP    STMLE
   101021    644GIOF: JMP    LIOl

   101022  73077HALTI:73077
   101023     2C2:   2
   101024     1FIRST:1
   101025   100C100: 100
   101026 177700CM100:-100
   101027 176000M2000:-2000
   101030     1MPNC: 1
   101031     4C4:   4
   101032  2001CINC: 2001
   101033  2000C2K:  2000



   101034 177777MTSF: 177777

   101035     1AC0S: 1
   101036     1AClS: 1


   101037  34630MERR: LDA    3,MAPN
   101040  63077      HALT   ;A0=S\B, Al=IS, A2=ADDR, A3=MAP

   101041  77077MRET: 77077
```

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---
   101042  54777STBL: STA    3,MRET    ;SETUP TABLE FOR LOGICAL=PHYSICAL
   101043   4525      JSR    JTBL      ;PICKUP TABLE ADDR
   101044 102400      SUB    0,0       ;MTSF:A2:0
   101045  40767      STA    0,MTSF
   101046  24760      LDA    1,CM100   ;A1:-100
   101047  30763      LDA    2,CINC    ;PAGE INC. CONST.
   101050  41400STLP: STA    0,0,3     ;MAKE TBL ENTRY
   101051 175400      INC    3,3
   101052 143000      ADD    2,0
   101053 125404      INC    1,1,SZR   ;DONE WITH TABLE ?
   101054    774      JMP    STLP      ;NO
   101055 102000      ADC    0,0       ;A0:177777
   101056  41400      STA    0,0,3     ;STOP END OF TABLE
   101057  34762      LDA    3,MRET
   101060   1400      JMP    0,3

   101061  54002PKUP: STA    3,2
   101062  31400      LDA    2,0,3
   101063   5401      JSR    1,3
         101064 REF2=.


- PAGE 13 -
   101064  54755STMH: STA    3,MRET    ;SETUP TO TEST MEM ABOVE SELF
   101065  40750      STA    0,AC0S
   101066  50736      STA    2,FIRST
   101067   4501      JSR    JTBL      ;PICKUP TABLE ADDR
   101070  20743      LDA    0,C2K
   101071  24735      LDA    1,CM100
   101072    403      JMP    .+3
   101073 125400      INC    1,1
   101074 175400      INC    3,3
   101075 112443      SUBO   0,2,SNC   ;CALC 1ST PAGE ABOVE SELF
   101076    775      JMP    .-3
   101077  20731      LDA    0,MPNC
   101100  44736      STA    1,AC1S
   101101  30725      LDA    2,CM100
   101102 146400      SUB    2,1       ;DONT MAP OUT SELF
   101103  30727      LDA    2,CINC    ;PAGE INC. CONST.
   101104 124000      COM    1,1
   101105 143000      ADD    2,0
   101106 125404      INC    1,1,SZR
   101107    776      JMP    .-2
   101110 175400      INC    3,3
   101111  24725      LDA    1,AC1S
   101112  41400      STA    0,0,3
   101113 143000      ADD    2,0
   101114 175400      INC    3,3
   101115 125404      INC    1,1,SZR   ;DONE WITH TBL ?
   101116    774      JMP    .-4       ;NO
   101117   4451      JSR    JTBL
   101120 171000      MOV    3,2
   101121   4442      JSR    MPLD      ;LOAD MAP
   101122  34713      LDA    3,AC0S
   101123  20712      LDA    0,AC0S
   101124 102040      ADCO   0,0
   101125   2714      JMP    @MRET     ;ACTIVATE MAP ON RETURN
```

(9)

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- PAGE 14 -
  101126 175400STML: INC    3,3       ;SETUP TO TEST MEM BELOW SELF
  101127  54712       STA    3,MRET
  101130  34556       LDA    3,NWDS
  101131 173000       ADD    3,2
  101132  50440       STA    2,LAST
  101133  20700       LDA    0,C2K     ;PAGE SIZE
  101134 126400       SUB    1,1
  101135   4433       JSR    JTBL      ;GET TABLE ADDR
  101136    402       JMP    .+2
  101137 125400       INC    1,1
  101140 112443       SUBO   0,2,SNC   ;CALC LAST PAGE BELOW SELF
  101141    776       JMP    .-2
  101142 124000       COM    1,1       ;-(NO. PAGES)
  101143  20665       LDA    0,MPNC
  101144  30666       LDA    2,CINC    ;PAGE INC CONST
  101145 125405       INC    1,1,SNR
  101146    405       JMP    .+5
  101147  41400       STA    0,0,3     ;MAKE TABLE ENTRY                    (9)
  101150 175400       INC    3,3
  101151 143000       ADD    2,0
  101152    773       JMP    .-5
  101153   4415STMLE:JSR    JTBL
  101154 171000       MOV    3,2
  101155   4406       JSR    MPLD      ;LOAD MAP
  101156  34414       LDA    3,LAST
  101157  30644       LDA    2,C2
  101160  50644       STA    2,FIRST   ;PROTECT LOC 0
  101161 102040       ADCO   0,0
  101162   2657       JMP    @MRET     ;ACTIVATE MAP ON RETURN

  101163  20404MPLD: LDA    0,MUSR
  101164  61002       DOA    0,2       ;SELECT USER MAP
  101165  73002       DOC    2,2       ;LOAD FROM TABLE
  101166   1400       JMP    0,3

  101167 100000MUSR: 100000

  101170    523JTBL: JMP    CTBL
  101171    622JJTP: JMP    JTP1
  101172      1LAST: 1
```

```
; SOME MUX AND TAPE I/O TESTS

; MUX TEST: SWITCHES MUX INTO TEST MODE, THEN WRITES OUT ALL BYTES FROM
; 0 THROUGH 377 INCLUSIVE TO EACH PORT IN TURN, CHECKING THAT EACH BYTE IS
; CORRECTLY RECEIVED VIA THE ON-BOARD MUX LOOPBACK HARDWARE.


       101173 MUXTB:;MUX PARAMETER TABLE

  101173  61012CMDO: DOA    0,12     ;INITIAL VALUE OF COMMAND OUT INSTRUCTION
  101174  61013DATO: DOA    0,13     ;INITIAL VALUE OF DATA OUT INSTRUCTION
  101175  64412STATI:DIA    1,12     ;INITIAL VALUE OF STATUS IN INSTRUCTION
  101176  64413DATI: DIA    1,13     ;INITIAL VALUE OF DATA IN INSTRUCTION
  101177      0MDATA:0      ;DATA TO BE OUTPUT
  101200      1RMASK:1      ;INPUT STATUS MASK (RECEIVER FULL)
  101201      3PRST: 3      ;PORT CONTROL WORD (RESET)
  101202     31PCON: 31     ;PORT CONTROL WORD (8 BIT, EVEN PARITY, 1 STOP)
  101203    377LPAT: 377    ;LAST PATTERN                                    (12)
  101204 177771MNPTS:-7     ;MINUS MAXIMUM PORT NUMBER
  101205      0WAIT: 0
  101206    653JJPK: JMP    PKUP

  101207   4777MUXT: JSR    JJPK     ;SAVE ADDRESS OF LAST TEST STARTED AT LOCN. 2
  101210  63077       HALT
  101211   4610       JSR    GIOF     ;GET I/O FLAG
  101212 101014       SKZ    0,0      ;I/O TO BE TESTED ?
  101213    560       JMP    MOVE     ; NO, CONTINUE
  101214  20765       LDA    0,PRST   ; YES, ISSUE PORT RESET COMMAND TO ALL PORTS
  101215  24756       LDA    1,CMDO
  101216  30766       LDA    2,MNPTS
  101217   4432       JSR    CMD
  101220  20762       LDA    0,PCON   ;ISSUE PORT PARAMETERS (7 BIT, EVEN PARITY, 1
  101221  24752       LDA    1,CMDO
  101222  30762       LDA    2,MNPTS
  101223   4426       JSR    CMD
  101224  61070       DOA    0,70     ;SWITCH ON MUX TEST MODE

  101225  20752WDATA:LDA    0,MDATA
  101226  24746       LDA    1,DATO
  101227  30755       LDA    2,MNPTS
  101230   4421       JSR    CMD
  101231  24745TEST: LDA    1,DATI
  101232  44426       STA    1,RDATA
  101233  24742       LDA    1,STATI
  101234  44405       STA    1,RSTAT
  101235  30747       LDA    2,MNPTS
  101236  34742       LDA    3,RMASK
  101237 126400       SUB    1,1
  101240  44745       STA    1,WAIT
```

- PAGE 16 -

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101241  64412RSTAT:DIA    1,12      ;***** GETS MODIFIED BY PROGRAM *****
101242 137415       AND#   1,3,SNR
101243    402       JMP    .WAIT
101244    414       JMP    RDATA

101245  10740.WAIT:ISZ    WAIT      ;TIMED OUT ?
101246    773       JMP    RSTAT     ; NO, CONTINUE
101247  61071       DOA    0,71      ;SWITCH OFF MUX TEST MODE
101250  63077       HALT   ; YES, TIMED OUT !

101251  44401CMD:   STA    1,CMD+1   ;A0=COMMAND, A1=INSTRUCTION, A2=MINUS NUMBER C
101252  61012       DOA    0,12      ;***** GETS MODIFIED BY PROGRAM *****
101253  10777       ISZ    CMD+1     ;MODIFY INSTRUCTION ...
101254  10776       ISZ    CMD+1     ; ... TO ADDRESS NEXT PORT
101255 151404       INC    2,2,SZR   ;FINISHED ALL PORTS ?
101256    774       JMP    CMD+1     ; NO, CONTINUE
101257   1400       JMP    0,3       ; YES, RETURN

101260  64413RDATA:DIA    1,13      ;***** GETS MODIFIED BY PROGRAM *****
101261 106414       SEQ    0,1       ;CHECK LOOPBACK DATA
101262  63077       HALT   ;FAILED ! A0 = SHOULD BE, A1 = IS
101263  10756       ISZ    RSTAT     ;MODIFY INSTRUCTION ...
101264  10755       ISZ    RSTAT     ; ... TO ADDRESS NEXT PORT
101265  10773       ISZ    RDATA     ;MODIFY INSTRUCTION ...
101266  10772       ISZ    RDATA     ; ... TO ADDRESS NEXT PORT
101267 151404       INC    2,2,SZR   ;DONE ALL PORTS ?                    (12)
101270    751       JMP    RSTAT     ; NO, TEST NEXT PORT
101271  24712       LDA    1,LPAT    ; YES, MOVE ON TO NEXT DATA PATTERN
101272 106415       SNE    0,1       ;DONE 0 THROUGH 377 PATTERNS ?
101273    403       JMP    MXEND     ; YES, EXIT
101274 101400       INC    0,0       ; NO, INCREMENT (A0) TO NEXT PATTERN ...
101275    731       JMP    WDATA+1   ; ... AND CONTINUE
101276  61071MXEND:DOA    0,71      ;SWITCH OFF MUX TEST

101277   4672       JSR    JJTP
101300  20040       .TXT   "<40><40>
101301  46525MU
101302  54040X
101303  47513OK
101304  26000,"

101305    407       JMP    TPTST

101306 175743NWDS: SELF-END-200
101307  23023R.MIN:DIST-END-200+REF2-1
101310  25065R.MAX:DIST+REF2-SELF+4
101311   1264R.OFS:REF2-SELF
101312    220TCMD: 220
101313    521CTBL: JMP    BTBL
```

```
; TAPE TEST: SWITCHES TAPE INTO TEST MODE, THEN WRITES OUT ALL BYTES FROM
; 0 THROUGH 377 INCLUSIVE, CHECKING THAT EACH BYTE IS CORRECTLY STORED AND
; RETREIVED FROM THE ON-BOARD TAPE LOOPBACK HARDWARE.

101314   4672TPTST:JSR    JJPK
101315      0      0
101316  20661       LDA    0,MDATA
101317  30664       LDA    2,LPAT
101320  61072       DOA    0,72      ;SWITCH ON TAPE TEST MODE
101321  61062       DOA    0,62      ;OUTPUT DATA PATTERN TO TAPE LOOPBACK REGISTEF
101322  71000       DOA    2,0       ;SET DATA BUS TO 377
101323  64461       DIA    1,61      ;READ DATA FROM TAPE LOOPBACK REGISTER
101324 106414       SEQ    0,1       ;TEST DATA READ BACK. EQUAL ?
101325  63077       HALT   ; NO, FAILED! A0 = SHOULD BE, A1 = IS
101326 112415       SNE    0,2       ; YES, DONE ALL PATTERNS ?
101327    403       JMP    TPEND     ;      YES, EXIT TAPE TEST
101330 101400       INC    0,0       ;      NO, INCREMENT A0 ...
101331    766       JMP    TPTST+3   ;      ... AND CONTINUE TEST WITH NEXT PATTERN
101332  61073TPEND:DOA    0,73      ;SWITCH OFF TAPE TEST MODE
101333   4636       JSR    JJTP
101334  20040       .TXT   "
101335  52101TA
101336  50105PE
101337  20114 L
101340  47507OG
101341  44503IC
101342  20117 O
101343  45454K,
101344      0"
```

(11)

```
; DISC CONTROLLER SELFTEST...ISSUE TST TO WD BOARD, CHK STATUS
101345   4641DTST: JSR    JJPK
101346      0      0
101347  20743       LDA    0,TCMD
101350  61057       DOA    0,57      ;ISSUE TEST COMMAND TO WD BOARD
101351  64457DSTAT:DIA    1,57      ;GET DISK STATUS
101352 125300       MOVS   1,1
101353 125112       MOVL#  1,1,SZC   ;WAIT FOR NOT BUSY
101354    775       JMP    DSTAT
101355  60451       DIA    0,51      ;READ ERROR REGISTER
101356 101004       MOV    0,0,SZR   ;ANY ERROR ?
101357  63077       HALT   ; YES, FAILED... A0= ERROR STATUS
101360   4611       JSR    JJTP      ; NO, CONTINUE
101361  20040       .TXT   "<40><40>
101362  42111DI
101363  51503SC
101364  20114 L
101365  47507OG
101366  44503IC
101367  20117 O
101370  45456K.
101371      0"

101372    401       JMP    MOVE
```

(10)

```
; MOVE TEST PGM THRU CORE + REPEAT

101373   4613MOVE: JSR    JJPK      ;*** GETS MODIFIED TO SKP MOVE IF AUTO IPL ***
101374 130406      -DIST*2           ;TENT. ASSUME DOUBLE MOVE REQUIRED
101375  20712      LDA    0,R.MIN
101376  24712      LDA    1,R.MAX
101377 162433      SLE    3,0       ;IS SELF WHERE SINGLE MOVE WOULD
101400 166033      SLS    3,1       ;    CAUSE STRADDLING WORDS 0-3 ?
101401 151240      MOVOR  2,2       ;  NO, THEN DO SINGLE MOVE
101402  21604      LDA    0,TOPWD-REF2,3
101403  24706      LDA    1,R.OFS
101404 136400      SUB    1,3       ;A3 = CURRENT LOC. OF SELF
101405 173000      ADD    3,2
101406 113400      AND    0,2       ;A2 = NEW LOCATION OF SELF
101407  24677      LDA    1,NWDS
101410  21400MOVLP:LDA    0,0,3     ;NOW DO THE MOVE LOOP
101411  41000      STA    0,0,2
101412 175400      INC    3,3
101413 151400      INC    2,2
101414 125404      INC    1,1,SZR   ;MOVE DONE ?                                  (13)
101415    773      JMP    MOVLP     ;  NO
101416  24670      LDA    1,NWDS
101417 133000      ADD    1,2
101420  50000      STA    2,0       ;FOR EASILY FINDING SELF WHEN MOVED
101421   1000      JMP    0,2

101422  62677IPL:  IORST  ;AUTO IPL
101423  20405      LDA    0,POFST
101424  24405      LDA    1,PNWDS
101425  30405      LDA    2,PADDR
101426  34405      LDA    3,PBEGN
101427  60077      NIO    77
101430   7200POFST:7200
101431    200PNWDS:200
101432  20000PADDR:20000
101433  20024PBEGN:20000+24          ;LITERAL OFFSET IN MANIP

101434   5400BTBL: JSR    0,3       ;PICKUP LAST ADDRESS + 1 (BEGIN MAP TABLE)

      23575 DIST=23575
     101435 END=.
        143 .LOC  SELF+2000-.        ;OVERFLOW TEST
```

1.7 MARK 4E SELF-TEST LISTING

The individual tests on the following MARK 4E CPU Self-Test listing are numbered to correlate with the test descriptions given in Section 1.4.

MARK 4E SELF-TEST LISTING (1 of 23)

```
- PAGE 9 -

;*****************************************************************
;POINT 4 DATA CORPORATION MARK 4E CPU SELF TEST PROGRAM
;EDITED FOR THE MARK 4E BY BRUCE DOAN
;INITIAL RELEASE APRIL, 1987 - LAST EDITED DECEMBER 16, 1987
;*****************************************************************

;                All Rights Reserved
;     Copyright (C) 1986, Point 4 Data Corporation
;
             1        .TXTM  1          ;SPECIFY TEXT PACKING LEFT TO RIGHT

         20000        .LOC   L.SELF     ;

   20000    411 SELF0:JMP    SELFTEST ;NORMAL SELFTEST ENTRY POINT.
   20001    402 SELF1:JMP    ST1A     ;POWER-UP ENTRY POINT (FRONT PANEL SWITCH =
                                      ;ON)
   20002    404 SELF2:JMP    ST2A     ;POWER-UP RESTART (FRONT PANEL SWITCH =
                                      ;AUTO)

   20003 102000 ST1A: ADC    0,0      ;A0=177777
   20004  40543       STA    0,PWRUP  ;SET POWER-UP FLAG (FRONT PANEL SWITCH = ON)
   20005    404       JMP    SELFTEST ;

   20006 102000 ST2A: ADC    0,0      ;A0=177777
   20007  40541       STA    0,PUIPL  ;SET POWER-UP AND IPL REQUIRED FLAG (FRONT
                                      ;PANEL SWITCH = AUTO)
   20010    401       JMP    SELFTEST ;

   20011    401 SELFTEST:JMP .+1      ;                                          (1)

; TEST UNCONDITIONAL SKIP CAPABILITY

   20012 101020       MOVZ   0,0      ;TEST NON-SKIP
   20013 101021       MOVZ   0,0,SKP  ;TEST UNCONDITIONAL SKIP (WITH C = ZERO)
   20014  63077       HALT

   20015 125040       MOVO   1,1
   20016 125041       MOVO   1,1,SKP  ;UNCONDITIONAL SKIP (WITH C = 1)
   20017  63077       HALT

   20020 152400       SUB    2,2
   20021 152401       SUB    2,2,SKP  ;UNCONDITIONAL SKIP (WITH ZERO RESULT)
   20022  63077       HALT

   20023 176000       ADC    3,3
   20024 176001       ADC    3,3,SKP  ;UNCONDITIONAL SKIP (WITH NON-ZERO RESULT)
   20025  63077       HALT

; TEST SKIP USING CARRY CONDITION

   20026 101042       MOVO   0,0,SZC
   20027 101062       MOVC   0,0,SZC  ;SKIP ON ZERO CARRY
   20030  63077       HALT

   20031 101023       MOVZ   0,0,SNC
   20032 101063       MOVC   0,0,SNC  ;SKIP ON NON-ZERO CARRY
   20033  63077       HALT
```

```
---
; TEST SKIP USING (ZERO OR NON-ZERO) RESULT CONDITION

   20034 102004       ADC    0,0,SZR
   20035 102404       SUB    0,0,SZR  ;SKIP ON ZERO RESULT, USING A0
   20036  63077       HALT

   20037 126405       SUB    1,1,SNR
   20040 125405       INC    1,1,SNR  ;SKIP ON NON-ZERO RESULT, USING A1
   20041  63077       HALT

   20042 152004       ADC    2,2,SZR
   20043 150004       COM    2,2,SZR  ;SKIP ON ZERO RESULT, USING A2
   20044  63077       HALT

   20045 176004       ADC    3,3,SZR
   20046 175404       INC    3,3,SZR  ;SKIP ON ZERO RESULT, USING A3
   20047  63077       HALT

; TEST COMBINED SKIP CONDITION (BOTH NON-ZERO OR EITHER ZERO)

   20050 126027       ADCZ   1,1,SBN  ;RESULT = NON-ZERO, BUT C = ZERO
   20051 126407       SUB    1,1,SBN  ;RESULT = ZERO, BUT C = NON-ZERO
   20052 126007       ADC    1,1,SBN  ;RESULT AND CARRY BOTH NON-ZERO
   20053  63077       HALT

   20054 152040       ADCO   2,2      ;RESULT = NON-ZERO, CARRY = NON-ZERO
   20055 152410       SUB#   2,2      ;SHOULD NOT CHANGE RESULT (BECAUSE #)
   20056 151030       MOVZ#  2,2      ;SHOULD NOT CHANGE CARRY (BECAUSE #)   (1)
   20057 151006       MOV    2,2,SEZ  ;SKIP IF EITHER ZERO
   20060    402       JMP    .+2      ;JUMP OVER HALT IF NO SKIP
   20061  63077       HALT

; TEST SOME LOAD AND ALU INSTRUCTIONS

   20062  20450       LDA    0,C0     ;LOAD A0 = 0
   20063 126400       SUB    1,1      ;SET A1 = 0
   20064 106414       SEQ    0,1
   20065  63077       HALT

   20066  30443       LDA    2,C1     ;LOAD A2 = 1
   20067 176520       SUBZL  3,3      ;SET A3 = 1
   20070 156414       SEQ    2,3
   20071  63077       HALT

   20072  20441       LDA    0,CM1    ;LOAD A0 = 177777 (-1)
   20073 152000       ADC    2,2      ;SET A2 = 177777 (-1)
   20074 112414       SEQ    0,2
   20075  63077       HALT

   20076  24436       LDA    1,CM2    ;LOAD A1 = 177776 (-2)
   20077 176120       ADCZL  3,3      ;SET A3 = 177776 (-2)
   20100 136414       SEQ    1,3
   20101  63077       HALT

   20102  34433       LDA    3,C100K  ;LOAD A3 = 100000
   20103 102620       SUBZR  0,0      ;SET A0 = 100000
   20104 162414       SEQ    3,0
   20105  63077       HALT
```

```
---
   20106  30430        LDA    2,M100K  ;LOAD A2 = 77777
   20107 126220        ADCZR  1,1      ;SET A1 = 77777
   20110 146414        SEQ    2,1
   20111  63077        HALT

   20112 102120        ADCZL  0,0      ;A0 = 177776, C = 1
   20113 101112        MOVL#  0,0,SZC  ;TEST MSB: SHOULD BE = 1
   20114 101212        MOVR#  0,0,SZC  ;TEST LSB: SHOULD BE = 0
   20115  63077        HALT
   20116 101302        MOVS   0,0,SZC  ;TEST C = 1: SWAP SHOULD NOT AFFECT CARRY
   20117 101362        MOVCS  0,0,SZC  ;COMPLEMENT CARRY, NOW TEST C = 0
   20120  63077        HALT

   20121 126520        SUBZL  1,1      ;A1 = 1, C = 0
   20122 125113        MOVL#  1,1,SNC  ;TEST MSB: SHOULD BE = 0
   20123 125213        MOVR#  1,1,SNC  ;TEST LSB: SHOULD BE = 1
   20124  63077        HALT
   20125 125303        MOVS   1,1,SNC  ;TEST C = 0: SWAP SHOULD NOT AFFECT CARRY
   20126 125363        MOVCS  1,1,SNC  ;COMPLEMENT CARRY, NOW TEST C = 1
   20127  63077        HALT
   20130    421        JMP    TSWAP

   20131      1 C1:    1
   20132      0 C0:    0
   20133 177777 CM1:   -1
   20134 177776 CM2:   -2
   20135 100000 C100K:100000                                              (1)
   20136  77777 M100K:77777
   20137 100000 B0:    100000
   20140  40000 B1:    40000
   20141  20000 B2:    20000
   20142  10000 B3:    10000
   20143   4000 B4:    4000
   20144   2000 B5:    2000
   20145   1000 B6:    1000
   20146    400 B7:    400
   20147      0 PWRUP: 0              ;POWER-UP FLAG
   20150      0 PUIPL: 0              ;POWER-UP AND FRONT PANEL SWITCH = AUTO
                                      ;FLAG

; TEST EACH SWAP INPUT TO SHIFTER

   20151  20766 TSWAP: LDA    0,B0
   20152 105300        MOVS   0,1
   20153 131300        MOVS   1,2
   20154 106414        SEQ    0,1
   20155 112414        SEQ    0,2
   20156  63077        HALT

   20157  24761        LDA    1,B1
   20160 135300        MOVS   1,3
   20161 161300        MOVS   3,0
   20162 136414        SEQ    1,3
   20163 122414        SEQ    1,0
   20164  63077        HALT

   20165  30754        LDA    2,B2
   20166 141300        MOVS   2,0
   20167 115300        MOVS   0,3
```

```
---
   20170 142414        SEQ    2,0
   20171 156414        SEQ    2,3
   20172  63077        HALT

   20173  34747        LDA    3,B3
   20174 171300        MOVS   3,2
   20175 145300        MOVS   2,1
   20176 172414        SEQ    3,2
   20177 166414        SEQ    3,1
   20200  63077        HALT

   20201  20742        LDA    0,B4
   20202 111300        MOVS   0,2
   20203 155300        MOVS   2,3
   20204 112414        SEQ    0,2
   20205 116414        SEQ    0,3                                    (1)
   20206  63077        HALT

   20207  24735        LDA    1,B5
   20210 121300        MOVS   1,0
   20211 111300        MOVS   0,2
   20212 122414        SEQ    1,0
   20213 132414        SEQ    1,2
   20214  63077        HALT

   20215  30730        LDA    2,B6
   20216 155300        MOVS   2,3
   20217 165300        MOVS   3,1
   20220 156414        SEQ    2,3
   20221 146414        SEQ    2,1
   20222  63077        HALT

   20223  34723        LDA    3,B7
   20224 165300        MOVS   3,1
   20225 121300        MOVS   1,0
   20226 166414        SEQ    3,1
   20227 162414        SEQ    3,0
   20230  63077        HALT
```

```
; A FEW MORE BASIC ALU TESTS

   20231 102001 STALU:ADC    0,0,SKP  ;A0 = 177777
   20232  63077        HALT           ;UNCONDITIONAL "SKP" FAILED TO SKIP
   20233 126424        SUBZ   1,1,SZR  ;A1=0
   20234  63077        HALT
   20235 152000        ADC    2,2
   20236 151404        INC    2,2,SZR  ;A2=0
   20237  63077        HALT
   20240 176000        ADC    3,3
   20241 162415        SNE    3,0      ;A3,A0 SHOULD = 177777
   20242 132414        SEQ    1,2      ;A1,A2 SHOULD = 0              (2)
   20243  63077        HALT

; A FEW BASIC JMP, LDA, STA, ISZ TESTS USING RELATIVE ADDRESSING

   20244  20405        LDA    0,.+5
   20245 116414        SEQ    0,3
   20246  63077        HALT           ;A0 & A3 SHOULD = 177777
   20247  30666        LDA    2,C100K
```

```
---
   20250 102621        SUBZR  0,0,SKP
   20251 177777        177777
   20252 112414        SEQ    0,2
   20253  63077        HALT               ;A0 & A2 SHOULD = 100000
   20254    402        JMP    .+2         ;TEST JMP REL.
   20255  63077        HALT               ;SHOULD JUMP OVER THIS
   20256  40401        STA    0,.+1
   20257  63077 COM00: HALT               ;PGM CHANGES TO 100000=COM 0,0
   20260 112415        SNE    0,2
   20261  63077        HALT               ;A0 SHOULD = 77777, A2 = 100000
   20262 100000        COM    0,0
   20263  24774        LDA    1,COM00
   20264 112415        SNE    0,2
   20265 132414        SEQ    1,2
   20266  63077        HALT               ;A0, A1, A2 SHOULD = 100000
   20267   4403        JSR    JMP3        ;TEST INSTRS. USED IN "TYPE" S\R
   20270  63077 HLT1: 63077
   20271  77077 HLT2: 77077                                              (2)
   20272  54002 JMP3: STA    3,2         ;LOC. 2 --> LAST TEST BEGUN
   20273  25400        LDA    1,0,3
   20274  20774        LDA    0,HLT1
   20275 106414        SEQ    0,1
   20276  63077        HALT               ;A0 & A1 SHOULD = 63077 = (HLT1)
   20277 175420        INCZ   3,3
   20300  25400        LDA    1,0,3
   20301  20770        LDA    0,HLT2
   20302 106414        SEQ    0,1
   20303  63077        HALT               ;A0 & A1 SHOULD = 77077 = (HLT2)
   20304    406        JMP    TISZ

   20305      1 CNTR: 1

   20306  20641 LPUF: LDA    0,PWRUP     ;A0 = STATE OF POWER-UP FLAG
   20307   1400        JMP    0,3         ;RETURN

   20310  20640 LIPLF:LDA    0,PUIPL     ;A0 = STATE OF POWER-UP/IPL FLAG
   20311   1400        JMP    0,3         ;RETURN

   20312 102400 TISZ: SUB    0,0
   20313  40772        STA    0,CNTR
   20314  10771        ISZ    CNTR        ;TEST ISZ AND DSZ INSTR'S
   20315  14770        DSZ    CNTR
   20316  63077        HALT
   20317  14766        DSZ    CNTR
   20320  10765        ISZ    CNTR
   20321  63077        HALT
```

```
; ALU TEST: CALCULATE CHECKSUM IN A3 BASED UPON EXECUTION OF ALL
; POSSIBLE ALU INSTRUCTIONS, THEN COMPARE WITH CANNED VALUE (X)

   20322 102020 TALU: ADCZ   0,0         ;GENERATE 177777
   20323  41400        STA    0,+0,3      ;STORE 177777 AT TPWD                (3)
   20324 177240        ADDOR  3,3         ;COMPLEMENT MSB
   20325 102220        ADCZR  0,0         ;GENERATE 77777
   20326  41400        STA    0,+0,3      ;STORE 77777 ... AT TPWD IF 32KW
                                          ;            ... AT (TPWD + 100000) .. OR,
                                          ;            ... (TPWD - 100000) IF 64KW
   20327   4453        JSR    PIKUP       ;(SKIPS NEXT WORD)
                       ;
```

```
   20330  42263 X:    42263  ;CHECKSUM FOR "EXHAUSTIVE ALU TEST"
                      ;
; EXHAUSTIVE TEST OF ALL ALU INSTRUCTIONS

   20331 176220       ADCZR  3,3       ;A3 = 77777 (ARBITRARY INITIAL COND. )
   20332 171300       MOVS   3,2       ;A2 = 177577
   20333 145520       INCZL  2,1       ;A2 = 177401
   20334 102620       SUBZR  0,0       ;A0 = 100000                          (4)
   20335  40401       STA    0,.+1

   20336  63077 ALUI: HALT             ;CYCLES THROUGH ALL ALU INSTR.
   20337 147100       ADDL   2,1       ; \
   20340 123100       ADDL   1,0       ;  } FOLD RESULT INTO A3
   20341 117100       ADDL   0,3       ; /
   20342  10774       ISZ    ALUI      ;MODIFY INSTRUCTION; ALL DONE ?
   20343    773       JMP    ALUI      ;  NO, CONTINUE
   20344  20764       LDA    0,X       ;  YES
   20345 162414       SEQ    3,0       ;IS FINAL RESULT CORRECT ?
   20346  63077       HALT             ;  NO, ALU ERROR

; BASE 3 ADDRESSING VS. PAGE ZERO

   20347   4433       JSR    PIKUP
   20350   1005 REF1-L.SELF+400        ;
   20351 172032       SGE    3,2       ;IS SELF ABOVE PAGE ZERO ?
   20352    433       JMP    TJSR      ;  NO, SKIP PZ TEST
   20353 176520       SUBZL  3,3       ;SET UP FOR PAGE ZERO TEST
   20354  20002       LDA    0,2
   20355  20777       LDA    0,.-1
   20356  40403       STA    0,LDA0
   20357 175400 B3LP: INC    3,3       ;  INCREMENT BY 1 WORD
   20360  55400       STA    3,0,3     ;INTO EACH WORD WRITE ITS OWN ADDRESS

   20361  20002 LDA0: LDA    0,2       ;*******GETS MODIFIED BY PROGRAM******
   20362 116414       SEQ    0,3       ;DID WE GET BACK WHAT WE WROTE?
   20363  63077       HALT             ;  NO
   20364  10775       ISZ    LDA0      ;MODIFY THE LOAD INSTRUCTION          (5)
   20365  20410       LDA    0,K377
   20366 162032       SGE    3,0       ;IS A3 < 377
   20367    770       JMP    B3LP      ;  NO, REPEAT LOOP
   20370    415       JMP    TJSR      ;YES, GO ON TO NEXT TEST
   20371   4731 JTALU:JSR    TALU
   20372  77777 TPWD: 77777
   20373    125 K125: 125
   20374      0 FLG1: 0
   20375    377 K377: 377
   20376 177600 CM200:-200
   20377  20226 ADR:  LDREL-200       ;USED IN RELATIVE ADDRESSING TEST

   20400    706 JLPUF :JMP   LPUF     ;JMP TO LOAD A0 WITH POWER-UP FLAG CONTENTS
                                      ;ROUTINE
   20401    707 JLIPLF:JMP   LIPLF    ;JMP TO LOAD AC WITH POWER-UP/IPL FLAG
                                      ;CONTENTS ROUTINE

; SUB-ROUTINE TO PICK UP POINTER TO CENTRAL REFERENCE POINT

   20402  54002 PIKUP:STA    3,2       ;LOC. 2 --> LAST TEST STARTED
   20403  31400       LDA    2,0,3     ;LOAD PARAMETER WORD
   20404   5401       JSR    1,3       ;SKIP-RETURN WITH POINTER TO "REF1"


         20405 REF1= .      ;REFERENCE POINT USED FOR ADDRESSING EXTENSION
```

```
; BASE 2, RELATIVE, AND INDIRECT ADDRESSING - ALL WITHIN +-200 OF HERE

   20405   4775 TJSR: JSR    PIKUP
   20406     21       LDREL-REF1
   20407 173000       ADD    3,2       ;CALC. LOC. OF "LDREL"
   20410  20766       LDA    0,CM200
   20411 143040       ADDO   2,0
   20412  40765       STA    0,ADR     ;SET UP "ADR" = LDREL - 200
   20413  35200       LDA    3,-200,2
   20414  20777       LDA    0,.-1     ;PICK UP BASE 2 INSTR.
   20415  34600       LDA    3,.-200
   20416  34777       LDA    3,.-1     ;PICK UP REL. ADDR. INSTR.
   20417  40403 SETAD:STA    0,LDAB2   ;SET UP BASE 2 INSTRUCTION
   20420  54406       STA    3,LDREL   ;SET UP REL. ADDR. INSTR.
   20421  24755       LDA    1,CM200                                    (6)
   20422  35200 LDAB2:LDA    3,-200,2  ;*** GETS MODIFIED BY PROGRAM ***
   20423  22754       LDA    0,@ADR
   20424 116414       SEQ    0,3       ;A0 = INDIR., A3 = BASE 2 ADDRESSING
   20425  63077       HALT             ;THEY DON'T MATCH !?
   20426  34600 LDREL:LDA    3,.-200   ;*** GETS MODIFIED BY PROGRAM ***
   20427 116414       SEQ    0,3
   20430  63077       HALT
   20431  10746       ISZ    ADR       ;INCREMENT INDIRECT ADDRESS
   20432  10770       ISZ    LDAB2     ;AND BASE 2 LOAD INSTRUCTION,
   20433  10773       ISZ    LDREL     ;AND RELATIVE LOAD INSTRUCTION
   20434 125404       INC    1,1,SZR   ;HAVE WE TESTED 200 LOCATIONS ?
   20435    765       JMP    LDAB2     ;  NOT YET, REPEAT LOOP
   20436  35000       LDA    3,0,2     ;PREPARE FOR 2ND 200 LOCATIONS
   20437  20777       LDA    0,.-1     ;PICK UP BASE 2 INSTR.
   20440  34400       LDA    3,.       ;PICK UP REL. ADDR. INSTR.
   20441 101002       MOV    0,0,SZC   ;HAVE WE DONE 2ND PASS ALREADY ?
   20442    755       JMP    SETAD     ;  NO, DO IT NOW

; CHECK FOR PIB AND TEST POWER-UP AND POWER-UP/IPL FLAGS ON
; FIRST PASS OF SELFTEST

   20443  20731 FRST: LDA    0,FLG1
   20444 126400       SUB    1,1
   20445 106414       SEQ    0,1       ;FIRST PASS ?
   20446    500       JMP    CPUOK     ;  NO
   20447 102000       ADC    0,0       ;  YES, SET FLAG
   20450  40724       STA    0,FLG1
   20451  20722 IOCK: LDA    0,K125    ;CHECK IF TAPE IS PRESENT
   20452  24723       LDA    1,K377
   20453  61072       DOA    0,72      ;TURN ON TAPE LOOPBACK
   20454  61062       DOA    0,62      ;SEND BYTE TO TAPE                 (7)
   20455  65000       DOA    1,0       ;CLEAR BUSS
   20456  64461       DIA    1,61      ;GET BACK BYTE
   20457 106415       SNE    0,1       ;SAME AS SENT ?
   20460    403       JMP    TST0      ;  YES, PIB PRESENT
   20461 102000       ADC    0,0       ;  NO, NO TAPE
   20462  40545       STA    0,FLG2
   20463  20710 TST0: LDA    0,K125
   20464  61070       DOA    0,70      ;TURN ON LOOPBACK
   20465  61013       DOA    0,13      ;SEND CHARACTER
   20466 152400       SUB    2,2
   20467  50502       STA    2,DLAY+1  ;CLEAR DELAY COUNTER
```

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---
   20470  30500        LDA    2,DLAY    ;DELAY LOOP
   20471  10500        ISZ    DLAY+1
   20472    777        JMP    .-1
   20473 151404        INC    2,2,SZR
   20474    775        JMP    .-3
   20475  24700        LDA    1,K377
   20476  65000        DOA    1,0       ;CLEAR BUSS
   20477  64413        DIA    1,13      ;GET BACK CHARACTER
   20500  61071        DOA    0,71      ;LOOPBACK OFF
   20501 106415        SNE    0,1       ;CHARACTER SAME AS SENT ?
   20502    410        JMP    TPM4      ;  YES
   20503  20524        LDA    0,FLG2    ;  NO
   20504 101014        SKZ    0,0       ;WAS TAPE ALSO BAD ?
   20505    402        JMP    SETF      ;  YES, NO PIB
   20506  63077        HALT              ;  NO, PORT 1 BAD !
   20507 102000 SETF:  ADC    0,0       ;NO PIB, THEREFORE ...
   20510  40564        STA    0,NIOF    ; ... RUN SELFTEST WITHOUT ...
   20511    446        JMP    JTMAP      ; ... PRINTOUT OR I/O TESTS

   20512   4521 TPM4:  JSR    PRINT     ;
   20513   6412        .TXT   "<15><12>
   20514  46501 MA
   20515  51113 RK
   20516  20064  4
   20517  42440 E
   20520  51505 SE
   20521  46106 LF
   20522  52105 TE
   20523  51524 ST
   20524  20122  R
   20525  42526 EV
   20526  27040 .
   20527  30456 1.
   20530  30000 0"


   20531   4647 CKFLG:JSR    JLPUF     ;CHECK POWER-UP FLAG
   20532 101213        SKO    0,0       ;POWER-UP AND FRONT PANEL SWITCH = ON ?
   20533    403        JMP    CKIPL     ;NO, CHECK POWER-UP/IPL FLAG
   20534  20474        LDA    0,EXT1A   ;A0=ADDRESS OF POWER-UP EXIT
   20535  42475        STA    0,@.MOV   ;MODIFY FIRST ADDRESS OF MOVE ROUTINE TO
                                        ;JUMP TO POWER-UP EXIT

   20536   4643 CKIPL:JSR    JLIPLF    ;CHECK POWER-UP/IPL FLAG
   20537 101213        SKO    0,0       ;POWER-UP AND FRONT PANEL SWITCH = AUTO ?
   20540    406        JMP    CPUOK     ;NO, PRINT CPU OK IF NIOF IS NOT CLEARED
   20541  20533        LDA    0,NIOF    ;YES, CHECK NO I/O FLAG FOR PIB INSTALLED
   20542 101014        SKZ    0,0       ;
   20543    403        JMP    CPUOK     ;NO PIB, CONTINUE SELFTEST
   20544  20465        LDA    0,EXT2A   ;A0=ADDRESS OF POWER-UP/IPL EXIT
   20545  42465        STA    0,@.MOV   ;MODIFY FIRST ADDRESS OF MOVE ROUTINE TO
                                        ;JUMP TO POWER-UP/IPL EXIT

   20546  20526 CPUOK:LDA    0,NIOF    ;
   20547 101014        SKZ    0,0
   20550    542        JMP    TMAP
   20551   4462        JSR    PRINT     ;CPU OK
   20552   6412        .TXT   "<15><12>
   20553  41520 CP

---
   20554  52440 U
   20555  47513 OK
   20556  26000 ,"

   20557    533 JTMAP:JMP    TMAP

   20560    622 JPKP: JMP    PIKUP     ;
```

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; SOME SUBROUTINES USED FOR PRINT AND PORT 0 TEST

20561  20407 PRNTR:LDA    0,DLAY   ;
20562 101404       INC    0,0,SZR
20563    777       JMP    .-1
20564  10405       ISZ    DLAY+1
20565    774       JMP    PRNTR    ;
20566  61071       DOA    0,71
20567   1400       JMP    0,3

20570 177774 DLAY: -4
20571      0       0
20572      0 CSAV: 0

20573 151100 TIMO: MOVL   2,2
20574  50776       STA    2,CSAV
20575  30773       LDA    2,DLAY
20576 151404       INC    2,2,SZR
20577    777       JMP    .-1
20600  10771       ISZ    DLAY+1
20601    402       JMP    .+2
20602  63077       HALT
20603 152400       SUB    2,2                                    (MISC)
20604  50765       STA    2,DLAY+1
20605  30765       LDA    2,CSAV
20606 151200       MOVR   2,2
20607   1400       JMP    0,3

20610  20000 .SELF:L.SELF          ;
20611  22034 END.: END
20612      1 CNT:  1               ;GENERAL PURPOSE COUNTER
20613    100 K100: 100             ;OCTAL 64
20614    200 C200: 200             ;OCTAL 128
20615   1776 C1776:1776            ;OCTAL 1022
20616    377 C377: 377
20617   1400 C1400:1400            ;OCTAL 768
20620  77400 C177L:77400
20621 177700 CN100:-100            ;OCTAL -64
20622   1000 C1K:  1000            ;OCTAL 512
20623   2000 K2K:  2000            ;OCTAL 1024
20624    377 PGADR:377             ;MAP RAM PHYSICAL PAGE ADDRESS
20625   1000 MRNT: 1000
20626  77377 TEMP3:77377
20627      0 FLG2: 0
20630    433 EXT1A:EXIT1-MOVE+400  ;JUMP TO POWER-UP EXIT ROUTINE INSTRUCTION
20631    435 EXT2A:EXIT2-MOVE+400  ;JUMP TO POWER-UP/IPL EXIT ROUTINE
                                   ;INSTRUCTION
20632  21763 .MOV: MOVE            ;STARTING ADDRESS OF SELFTEST MOVE ROUTINE

; PRINT-OUT SUBROUTINE...ALSO TESTS PORT 0
```

```
---
   20633  61070 PRINT:DOA    0,70      ;TURN ON MUX LOOPBACK
   20634  25400 PRNT1:LDA    1,0,3     ;GET 2 CHARACTERS
   20635 102400        SUB    0,0
   20636  40733        STA    0,DLAY+1
   20637 175420        INCZ   3,3       ;BUMP CHARACTER POINTER
   20640  54766        STA    3,TEMP3   ;SAVE CHARACTER POINTER
   20641  20757 PRNT2:LDA    0,C177L   ;DO LEFT BYTE 1ST
   20642 123705        ANDS   1,0,SNR   ;TERMINATOR ?
   20643    716        JMP    PRNTR     ;YES, EXIT
   20644  70410 PRNTL:DIA    2,10      ;NO, GET PORT 0 STATUS
   20645 151202        MOVR   2,2,SZC   ;ANYTHING IN REC. REG ?
   20646  63077        HALT             ;  YES, ABORT
   20647 151212        SKE    2,2       ;XMIT REG FULL ?
   20650    404        JMP    OPCHR     ;  NO, XMIT CHARACTER
   20651   4722        JSR    TIMO      ;  YES, CHECK TIMEOUT
   20652 151100        MOVL   2,2       ;RECONSTITUTE CARRY ...
   20653    771        JMP    PRNTL     ; ... AND CONTINUE WAIT
   20654  61011 OPCHR:DOA    0,11      ;OUTPUT CHARACTER
   20655 151100        MOVL   2,2       ;RESTORE CARRY
   20656 152460        SUBC   2,2
   20657  50712        STA    2,DLAY+1  ;RESET DELAY COUNTER
   20660  70410 RDSTA:DIA    2,10      ;READ PORT 0 STATUS
   20661 151212        SKE    2,2       ;RECEIVER EMPTY ?
   20662    403        JMP    GCHAR     ;  NO, GO TO GET CHARACTER
   20663   4710        JSR    TIMO      ;  YES, CHECK FOR TIMEOUT
   20664    774        JMP    RDSTA
   20665  70411 GCHAR:DIA    2,11      ;GET CHARACTER
   20666 112414        SEQ    0,2       ;SAME AS SENT ?
   20667  63077        HALT             ;  NO, ERROR ! AC0 = SHOULD BE, AC2 = IS
   20670  34736        LDA    3,TEMP3   ;RESTORE CHARACTER POINTER
   20671 125362        MOVCS  1,1,SZC   ;  YES, CONTINUE. DONE BOTH ?
   20672    747        JMP    PRNT2     ;   NO, NEXT CHARACTER

   20673    741        JMP    PRNT1     ;    YES, NEXT 2 CHARACTERS

   20674      0 NIOF:0                 ;NO I/O FLAG
```

MISC

```
; TEST MEMORY MAPPING RAMS
; TEST IF OLD OR NEW MAP THEN WRITE ALL VALUES FROM 377 (OLD)
; OR 1776 (NEW) THROUGH 1 INTO ALL LOCATIONS OF MAP RAMS.
; READ BACK, AND COMPARE.  REPEAT FOR ALL 4 MAPS.

   20675      0 TMFT0:0
   20676      0 TMFT1:0

   20677  54777 TMSB: STA    3,TMFT1   ;SAVE RETURN
   20700   4504        JSR    JJJMJ     ;A3:END OF PROGRAM+1 (START OF TBL)
   20701  30722        LDA    2,K2K     ;A2:2000
   20702  24717        LDA    1,CN100   ;A1:-100 TO FILL 64 WORDS
   20703  41400 TMS1: STA    0,0,3     ;FILL THE TABLE
   20704 175400        INC    3,3       ;BUMP POINTER
   20705 143000        ADD    2,0       ;ADJUST TO NEXT PAGE
   20706 125404        INC    1,1,SZR   ;TEST FOR DONE
   20707    774        JMP    TMS1      ;NOT YET
   20710  34766        LDA    3,TMFT1   ;RETURN
   20711   1400        JMP    0,3       ;WITHOUT INDIRECT

   20712   4646 TMAP: JSR    JPKP      ;(2):NXT ADDRESS A2:(NXT ADDRESS)
   20713      0        0
```

8

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---
20714  71002        DOA    2,2       ;INITIALIZE TO PMAP A
20715  50710        STA    2,MRNT    ;MRNT:0
20716  20677        LDA    0,C1776   ;A0:1776 TO ASSUME NEW MAP
20717   4760        JSR    TMSB      ;FILL TABLE
20720   4567        JSR    JJJJM     ;POINT TO TABLE
20721  77002        DOC    3,2       ;LDMP FROM TABLE
20722  76402        DIC    3,2       ;RDMP TO TABLE
20723  25400        LDA    1,0,3     ;A1:FIRST TABLE ENTRY
20724  20671        LDA    0,C1776   ;ASSUME NEW MAP
20725  30672        LDA    2,C1400   ;CONSTANT TO TEST NEW MAP
20726 147405        AND    2,1,SNR   ;MUST BE NEW MAP
20727  20667        LDA    0,C377    ;ELSE IT IS OLD MAP
20730  40745        STA    0,TMFT0   ;SAVE LAST PHYSICAL PAGE NO.



20731  20744 TMPR: LDA    0,TMFT0   ;LAST PHYSICAL PAGE NO.
20732  40672        STA    0,PGADR   ;TO PGADR

20733  20671 TMRL: LDA    0,PGADR   ;GET CURRENT VAL TO WRITE
20734   4743        JSR    TMSB      ;FILL TABLE WITH A0

20735  20670        LDA    0,MRNT    ;GET MAP TO LOAD
20736  61002        DOA    0,2       ;SELECT MAP FOR LOAD                    (8)
20737   4550        JSR    JJJJM     ;A3=STARTING ADDRESS OF MAP TABLE
20740  77002        DOC    3,2       ;LOAD MEMORY MAP

20741  30652        LDA    2,K100    ;A2=100 OCTAL (64 DECIMAL)
20742  50650        STA    2,CNT     ;INITIALIZE CNT (COUNTER) FOR 64 MAP
                                     ;ENTRIES
20743 173000        ADD    3,2       ;A2=END OF PREVIOUSLY CREATED MAP TABLE
                                     ;(A3)+1
20744  72402        DIC    2,2       ;READ MAP RAM CONTENTS AND PLACE IT
                                     ;STARTING AT A2

20745  25400 TCHK: LDA    1,0,3     ;FETCH CORRECT MAP RAM TABLE ENTRY
20746  21000        LDA    0,0,2     ;FETCH ENTRY JUST READ
20747 106414        SEQ    0,1       ;COMPARE ?
20750  63077        HALT             ;NO!  A0=CORRECT, A1=INCORRECT
20751 175400        INC    3,3       ;BUMP POINTERS IN BOTH MAP TABLES
20752 151400        INC    2,2       ;
20753  14637        DSZ    CNT       ;DONE WITH TABLE COMPARISON?
20754    771        JMP    TCHK      ;NO

20755  14647        DSZ    PGADR     ;HAVE ALL POSSIBLE PHYSICAL ADDRESS VALUES
                                     ;BEEN WRITTEN?
20756    755        JMP    TMRL      ;NO, DO NEXT

20757  20646        LDA    0,MRNT    ;YES, DONE ALL 4 MAPS?
20760  24634        LDA    1,C200    ;A1=200 OCTAL
20761 123000        ADD    1,0       ;INCREMENT TO THE NEXT MAP
20762  30640        LDA    2,C1K     ;A2=1000 OCTAL
20763 112415        SNE    0,2       ;TESTED ALL FOUR MEMORY MAPS?
20764    403        JMP    MAPOK     ;YES
20765  40640        STA    0,MRNT    ;NO, STORE NEXT MAP TABLE LOAD VALUE
20766    743        JMP    TMPR      ;
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   20767  20705 MAPOK:LDA    0,NIOF    ;TEST NO I/O FLAG
   20770 101014       SKZ    0,0       ;ZERO?
   20771    414       JMP    SZMEM     ;NO, DON'T DO PRINT OUT
   20772   4641       JSR    PRINT     ;YES, PRINT MAP OK

   20773  20040 .TXT"<40><40>
   20774  46501 MA
   20775  50040 P
   20776  47513 OK
   20777  26000 ,"
                ;MAP OK TEXT
   21000    405       JMP    SZMEM

   21001    632 JPRNT:JMP    PRINT

   21002  20672 LIOF: LDA    0,NIOF    ;A0=CONTENTS OF THE NO I/O FLAG
   21003   1400       JMP    0,3       ;RETURN TO CALLING ROUTINE

   21004    503 JJJMJ:JMP    JJJJM     ;

   21005  20507 SZMEM:LDA    0,MAPN    ;TIME TO TEST MEMORY WIDTH?
   21006 101004       MOV    0,0,SZR
   21007    513       JMP    TMEM-2    ;NO                                    (8)

; DETERMINE DEPTH OF SYSTEM MEMORY: 128KW, 256KW, 512KW OR 1MW
;                                   (256KB, 512KB,  1MB  OR 2MB)

   21010   4500 SIZEM:JSR    JSTB      ;SETUP MAP TABLE WITH LOGICAL PAGE=
                                       ;PHYSICAL PAGE
   21011   4462       JSR    CNGTB     ;ALTER LAST 4 TABLE ENTRIES
                                       ;NOTE: MAP IS NOW ACTIVATED
   21012  20663       LDA    0,TMFT0   ;TEST FOR OLD BOARD
   21013  30504       LDA    2,CMT1    ;177401
   21014 143004       ADD    2,0,SZR   ;(TMFT0)=377?
   21015    406       JMP    SIZ0      ;NO, MUST BE NEW MAP
   21016  30502       LDA    2,CMT2    ;A2:173777 OLD MAP
   21017  34502       LDA    3,CMT3    ;A3:4      OLD MAP
   21020  20426       LDA    0,CN2     ;INDEX TO .5MB
   21021  40426       STA    0,MSGINDX;
   21022    403       JMP    SIZ1      ;AND CONTINUE

   21023  34470 SIZ0: LDA    3,C.20    ;A3=20 OCTAL.  ASSUME SYSTEM MEMORY CONSISTS
                                       ;OF 16 BLOCKS OF 64KW EACH (2MB)
   21024  30471       LDA    2,TOPWD   ;A2=177777 (HIGHEST LOGICAL MEMORY ADDRESS)
   21025 102400 SIZ1: SUB    0,0       ;CLEAR A0 (TEST VALUE)
   21026  41000       STA    0,0,2     ;STORE A0 AT LOGICAL ADDR CONTAINED IN A2
   21027  25000       LDA    1,0,2     ;READ STORED VALUE INTO A1
   21030 106414       SEQ    0,1       ;WRITE = READ?
   21031    427       JMP    SIZ3      ;NO
   21032 100000       COM    0,0       ;YES, COMPLEMENT THE TEST VALUE AND TRY
                                       ;AGAIN
   21033  41000       STA    0,0,2     ;STORE AGAIN AT THE SAME LOCATION
   21034  25000       LDA    1,0,2     ;READ AGAIN
   21035 106414       SEQ    0,1       ;WRITE = READ?
   21036    422       JMP    SIZ3      ;NO
                                       ;YES, RECORD MEMORY SIZE IN MSIZ
   21037  54457 SIZ2: STA    3,MSIZ    ;MSIZ=SYSTEM MEMORY SIZE IN TERMS OF 64KW
                                       ;BLOCKS (16, 8, 4 OR 2)
   21040  54454       STA    3,MAPN    ;
```

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---
21041   4407        JSR    SIZ4      ;PICK UP MESSAGE ADDRESS
21042  20062        20062            ;<40><62>  2MB
21043  20061        20061            ;<40><61>  1MB
21044  27065        27065            ;<56><65> .5MB
21045  27062        27062            ;<56><62> .2MB

21046 177776 CN2:  -2                ;NEGATIVE 2 OCTAL
21047 177774 MSGINDX:-4              ;NEGATIVE 4 OCTAL

21050  20777 SIZ4: LDA    0,MSGINDX;LOAD A0 WITH INDEX POINTER (-4,-3,-2 OR
                                     ;-1)
21051 117000        ADD    0,3       ;CALCULATE TEXT ADDRESS
21052  21404        LDA    0,4,3     ;PICK UP MESSAGE
21053  40555        STA    0,MOKMG+1;AND STORE IT
21054 102400        SUB    0,0       ;CLEAR A0
21055  61002        DOA    0,2       ;DISABLE MAP STATUS
21056  62677        IORST            ;MAP OFF
21057    443        JMP    TMEM-2    ;FINISHED

                                     ;MODIFY MESSAGE INDEX
21060  20767 SIZ3: LDA    0,MSGINDX;LOAD A0 WITH INDEX POINTER TO SYSTEM
                                     ;MEMORY SIZE DESCRIPTOR TEXT
21061 101400        INC    0,0       ;INCREMENT POINTER TO NEXT LOWER SIZE
21062  40765        STA    0,MSGINDX;STORE NEW INDEX POINTER
21063  20573        LDA    0,M2000   ;A0=-2000
21064 113000        ADD    0,2       ;DECREMENT LOGICAL ADDRESS BY 2K
21065 175220        MOVZR  3,3       ;A3=A3/2.  DEVIDE SYSTEM MEMORY SIZE IN      (8)
                                     ;TERMS OF 64KW BLOCKS BY 2
21066  20427        LDA    0,TOPWD   ;A0=177777
21067 163004        ADD    3,0,SZR   ;DONE (A3=1)?
21070    735        JMP    SIZ1      ;NO
21071 175120        MOVZL  3,3       ;YES FORCE TO BE 2
21072    745        JMP    SIZ2

21073  54574 CNGTB:STA    3,MRET    ;SAVE RETURN ADDRESS TO CALLING PROGRAM
21074  24753        LDA    1,MSGINDX;A1=-4
21075   4412        JSR    JJJJM     ;A3=END OF SELFTEST+1 (START OF MAP TABLE)
21076  20556        LDA    0,C100    ;A0=100 OCTAL (64 DECIMAL)
21077  31474 CNGT1:LDA    2,74,3    ;CHANGE PHYSICAL ADDRESS IN LAST 4 MAP TABLE
21100 113000        ADD    0,2       ;ENTRIS TO BE:
21101  51474        STA    2,74,3    ;             0174  (A PHY PAGE IN 256KB)
21102 101120        MOVZL  0,0       ;             0275  (A PHY PAGE IN 256-512KB)
21103 175400        INC    3,3       ;             0476  (A PHY PAGE IN 512-1024KB)
21104 125404        INC    1,1,SZR   ;             1077  (A PHY PAGE IN 1024-2048KB)
21105    772        JMP    CNGT1     ;
21106    540        JMP    CNGXT     ;RETURN VIA @MRET WITH MAP ON

21107    561 JJJJM:JMP    JJJMT     ;ELEVATOR TO MTBL (BEGINNING OF MAP TABLE)
21110    561 JSTB: JMP    STBL      ;ELEVATOR TO STBL
21111    670 JJPR: JMP    JPRNT     ;ELEVATOR TO PRINT
21112    670 JLIOF:JMP    LIOF      ;ELEVATOR TO LIOF (LOAD ACCUMULATOR 0
                                     ;WITH THE CONTENTS OF THE NO I/O FLAG)

21113     20 C.20: 20              ;20 OCTAL (16 DECIMAL)
21114      0 MAPN: 0               ;
21115 177777 TOPWD:177777          ;LARGEST MEMORY ADDRESS
21116      0 MSIZ: 0               ;
21117 177401 CMT1: 177401          ;
21120 173777 CMT2: 173777          ;

---
21121      4 CMT3: 4               ;
```

```
; MEMORY TEST:  FIRST PASS: SET A BIT TO 1, SET IT TO 0, THEN SET
; IT BACK TO 1, THEN DO THE SAME TO NEXT BIT, ETC.
; SECOND PASS: TEST THAT THE BIT = 1, TOGGLE IT TO 0, RETEST,
; AND BACK TO 1, THEN DO SAME FOR NEXT BIT--
; THUS EACH BIT IS TESTED AFTER ALL OTHER BITS HAVE BEEN TOGGLED.
; THEN REPEAT THE WHOLE TEST WITH 0'S AND 1'S INTERCHANGED
; THIRD TEST: USE EACH WORD'S ADDRESS IN PLACE OF 0'S OR 1'S
; FOURTH TEST: USE 73077 HALT (HAS ODD PARITY) IN PLACE OF ADDRRESS

 21122 102400        SUB    0,0
 21123  40534        STA    0,MPNC
 21124   4764 TMEM:  JSR    JSTB
 21125   4563        JSR    PKUP
 21126    721        END+200-REF2
 21127 173000        ADD    3,2       ;A2 = FIRST LOC. ABOVE SELF-TEST
 21130  21602        LDA    0,TOPWD-REF2,3
 21131 101220        MOVZR  0,0       ;MIDPOINT OF AVAILABLE RAM
 21132 142033 SLS    2,0       ;ARE WE CURRENTLY ABOVE MIDPOINT ?
 21133   4507        JSR    JSTL      ;YES, TEST LOWER MEMORY
 21134   4507        JSR    JSTH      ;NO, TEST UPPER PORTION
 21135  30515 MTEST:LDA    2,FIRST   ;FIRST PASS - SET UP MEMORY
 21136 101003 LOOP1:MOV    0,0,SNC   ;IS THIS THE THIRD TEST ?
 21137 141000        MOV    2,0       ;  YES: USE ADDRESS
 21140  41000        STA    0,0,2
 21141 104000        COM    0,1
 21142  45000        STA    1,0,2     ;TOGGLE MEMORY WORD                    (9)
 21143  41000        STA    0,0,2     ;TOGGLE BACK AGAIN
 21144 151400        INC    2,2
 21145 156032        SGE    2,3       ;ALL SET UP ?
 21146    770        JMP    LOOP1     ;  NOT YET
 21147  30503        LDA    2,FIRST   ;SECOND PASS - TEST MEMORY
 21150 101003 LOOP2:MOV    0,0,SNC   ;ARE WE ON THE THIRD TEST ?
 21151 141000        MOV    2,0       ;  YES, USE ADDRESS
 21152  25000        LDA    1,0,2
 21153 106414        SEQ    0,1
 21154    441        JMP    MERR      ;ERROR
 21155 104000        COM    0,1
 21156  45000        STA    1,0,2     ;TOGGLE MEMORY
 21157  25000        LDA    1,0,2     ;RETEST
 21160 124000        COM    1,1
 21161 106414        SEQ    0,1
 21162    433        JMP    MERR      ;ERROR
 21163  41000        STA    0,0,2     ;TOGGLE MEMORY WORD BACK AGAIN
 21164 151400        INC    2,2
 21165 156032        SGE    2,3       ;TESTED ALL LOCATIONS ?
 21166    762        JMP    LOOP2     ;  NO
 21167 101466        INCC   0,0,SEZ   ;NOW PREPARE FOR NEXT TEST
 21170  20460        LDA    0,HALTI   ;GET THE HALT INSTRUCTION
 21171  24457        LDA    1,HALTI   ;GET 73077 INSTRUCTION
 21172 122014        ADC#   1,0,SZR   ;HAVE WE DONE FOUR TESTS?
 21173    742        JMP    MTEST     ;NO, DO NEXT TEST
 21174 102400        SUB    0,0
 21175  61002        DOA    0,2       ;DISABLE MAP
 21176  62677        IORST
 21177 102000        ADC    0,0
 21200  40464        STA    0,MTSF
 21201  14713        DSZ    MAPN      ;DONE ALL BLOCKS ?
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---
21202    402        JMP    .+2       ;NO
21203    414        JMP    MPASS     ;YES, EXIT
21204  34450        LDA    3,C100
21205  24707        LDA    1,MAPN
21206 124000        COM    1,1
21207 102400        SUB    0,0
21210 125405        INC    1,1,SNR
21211    713        JMP    TMEM      ;TEST NEXT BLK
21212 163000        ADD    3,0
21213  40444        STA    0,MPNC
21214    774        JMP    .-4

21215  34677 MERR:  LDA    3,MAPN
21216  63077        HALT   ;A0=S\B, A1=IS, A2=ADDR, A3=MAP

21217  20677 MPASS: LDA    0,MSIZ    ;
21220  40674        STA    0,MAPN    ;RESTORE BLOCK COUNTER
21221 102400        SUB    0,0       ;
21222  40435        STA    0,MPNC    ;RESTORE MPNC:0

21223   4667 MEMOK: JSR    JLIOF     ;A0:NIOF
21224 101014        SKZ    0,0       ;
21225    420        JMP    JDSKT     ;
21226   4663        JSR    JJPR      ;MEMORY OK
21227  20040 MOKMG:.TXT    "<40><40>
21230  20040 <40><40>                                                    (9)
21231  46502 MB
21232  20115  M
21233  42515 EM
21234  47522 OR
21235  54440 Y
21236  47513 OK
21237  26000 ,"

21240    405        JMP    JDSKT     ;

21241    650 JJJPR:JMP    JJPR      ;ELEVATOR TO PRINT
21242    513 JSTL: JMP    STML      ;ELEVATOR TO STML
21243    450 JSTH: JMP    STMH      ;ELEVATOR TO STMH
21244    546 JMLD: JMP    MPLD      ;ELEVATOR TO MPLD
21245    555 JDSKT:JMP    DISKT     ;ELEVATOR TO DISKT
21246    534 CNGXT:JMP    STMLE     ;ELEVATOR TO STMLE (LOAD MAP TABLE AND
                                    ;ACTIVATE VIA @MRET)
21247    643 JJLIO:JMP    JLIOF     ;ELEVATOR TO LIOF (LOAD ACCUMULATOR 0
                                    ;WITH THE CONTENTS OF THE NO I/O FLAG)

21250  73077 HALTI:73077           ;HALT INSTRUCTION
21251      2 C2:   2               ;2 OCTAL
21252      1 FIRST:1               ;
21253      1 LAST: 1               ;
21254    100 C100: 100             ;100 OCTAL
21255 177700 CM100:-100           ;NEGATIVE 100 OCTAL
21256 176000 M2000:-2000          ;MINUS 2000 OCTAL (2K)
21257      1 MPNC: 1               ;
21260   2001 CINC: 2001            ;
21261   2000 C2K:  2000            ;2048 IN OCTAL (2K)
21262 175544 NWDS: L.SELF-END-200 ;
21263 100000 MUSR: 100000         ;
21264 177777 MTSF: 177777         ;
```

```
---
   21265      1 AC0S: 1                ;
   21266      1 AC1S: 1                ;
   21267  77077 MRET: 77077
   21270    530 JJJMT:JMP    JJMTB     ;ELEVATOR TO MTBL (BEGINNING OF MAP TABLE)

   21271  54776 STBL: STA    3,MRET    ;SETUP MEMORY MAP TABLE FOR
                                        ;LOGICAL=PHYSICAL
   21272   4526        JSR    JJMTB     ;PICKUP MAP TABLE ADDRESS
   21273 102400        SUB    0,0       ;MTSF:A2:0
   21274  40770        STA    0,MTSF
   21275  24760        LDA    1,CM100   ;A1:-100
   21276  30762        LDA    2,CINC    ;PAGE INC. CONST.
   21277  41400 STLP: STA    0,0,3     ;MAKE TBL ENTRY
   21300 175400        INC    3,3
   21301 143000        ADD    2,0
   21302 125404        INC    1,1,SZR   ;DONE WITH TABLE ?
   21303    774        JMP    STLP      ;NO
   21304 102000        ADC    0,0       ;A0:177777
   21305  41400        STA    0,0,3     ;STOP END OF TABLE
   21306  34761        LDA    3,MRET
   21307   1400        JMP    0,3

   21310  54002 PKUP: STA    3,2
   21311  31400        LDA    2,0,3
   21312   5401        JSR    1,3
          21313 REF2=.

   21313  54754 STMH: STA    3,MRET    ;SETUP TO TEST MEM ABOVE SELF
   21314  40751        STA    0,AC0S                                    (9)
   21315  50735        STA    2,FIRST
   21316   4502        JSR    JJMTB     ;PICKUP MAP TABLE ADDRESS
   21317  20742        LDA    0,C2K
   21320  24735        LDA    1,CM100
   21321    403        JMP    .+3
   21322 125400        INC    1,1
   21323 175400        INC    3,3
   21324 112443        SUBO   0,2,SNC   ;CALC 1ST PAGE ABOVE SELF
   21325    775        JMP    .-3
   21326  20731        LDA    0,MPNC
   21327  44737        STA    1,AC1S
   21330  30725        LDA    2,CM100
   21331 146400        SUB    2,1       ;DONT MAP OUT SELF
   21332  30726        LDA    2,CINC    ;PAGE INC. CONST.
   21333 124000        COM    1,1
   21334 143000        ADD    2,0
   21335 125404        INC    1,1,SZR
   21336    776        JMP    .-2
   21337 175400        INC    3,3
   21340  24726        LDA    1,AC1S
   21341  41400        STA    0,0,3
   21342 143000        ADD    2,0
   21343 175400        INC    3,3
   21344 125404        INC    1,1,SZR   ;DONE WITH TBL ?
   21345    774        JMP    .-4       ;NO
   21346   4452        JSR    JJMTB     ;PICKUP MAP TABLE ADDRESS
   21347 171000        MOV    3,2
   21350   4442        JSR    MPLD      ;LOAD MAP
   21351  34714        LDA    3,AC0S
   21352  20713        LDA    0,AC0S
```

```
---
   21353 102040        ADCO    0,0
   21354   2713        JMP     @MRET     ;ACTIVATE MAP ON RETURN

   21355 175400 STML:  INC     3,3       ;SETUP TO TEST MEM BELOW SELF
   21356  54711        STA     3,MRET
   21357  34703        LDA     3,NWDS
   21360 173000        ADD     3,2
   21361  50672        STA     2,LAST
   21362  20677        LDA     0,C2K     ;PAGE SIZE
   21363 126400        SUB     1,1
   21364   4434        JSR     JJMTB     ;PICKUP MAP TABLE ADDRESS
   21365    402        JMP     .+2
   21366 125400        INC     1,1
   21367 112443        SUBO    0,2,SNC   ;CALC LAST PAGE BELOW SELF
   21370    776        JMP     .-2
   21371 124000        COM     1,1       ;-(NO. PAGES)
   21372  20665        LDA     0,MPNC
   21373  30665        LDA     2,CINC    ;PAGE INC CONST
   21374 125405        INC     1,1,SNR                                    (9)
   21375    405        JMP     .+5
   21376  41400        STA     0,0,3     ;MAKE TABLE ENTRY
   21377 175400        INC     3,3
   21400 143000        ADD     2,0
   21401    773        JMP     .-5
   21402   4416 STMLE: JSR     JJMTB     ;PICKUP MAP TABLE ADDRESS
   21403 171000        MOV     3,2
   21404   4406        JSR     MPLD      ;LOAD MAP
   21405  34646        LDA     3,LAST
   21406  30643        LDA     2,C2
   21407  50643        STA     2,FIRST   ;PROTECT LOC 0
   21410 102040        ADCO    0,0
   21411   2656        JMP     @MRET     ;ACTIVATE MAP ON RETURN

   21412  20651 MPLD:  LDA     0,MUSR
   21413  61002        DOA     0,2       ;SELECT USER MAP
   21414  73002        DOC     2,2       ;LOAD FROM TABLE
   21415   1400        JMP     0,3

   21416    623 JJJPT: JMP     JJJPR     ;ELEVATOR TO PRINT
   21417    671 JPKUP: JMP     PKUP      ;ELEVATOR TO PKUP
   21420    544 JJMTB: JMP     JMTBL     ;ELEVATOR TO MTBL (BEGINNING OF MAP TABLE)
   21421    220 TDCMD: 220               ;TEST DISK COMMAND
```

```
; DISC CONTROLLER SELFTEST...ISSUE TST TO WD BOARD, CHK STATUS

   21422   4775 DISKT: JSR     JPKUP     ;
   21423      0        0                 ;
   21424   4623        JSR     JJLIO     ;GET I/O FLAG
   21425 101014        SKZ     0,0       ;SHOULD I/O BE TESTED
   21426    575        JMP     JMOVE     ;NO, JUMP OVER DISK, TAPE, AND SERIAL PORT
                                         ;TESTS
   21427  20772        LDA     0, TDCMD  ;                                  (10)
   21430  61057        DOA     0,57      ;ISSUE TEST COMMAND TO WD BOARD
   21431  64457 DSTAT: DIA     1,57      ;GET DISK STATUS
   21432 125300        MOVS    1,1
   21433 125112        MOVL#   1,1,SZC   ;WAIT FOR NOT BUSY
   21434    775        JMP     DSTAT
   21435  60451        DIA     0,51      ;READ ERROR REGISTER
   21436 101004        MOV     0,0,SZR   ;ANY ERROR ?
```

```
---
   21437  63077        HALT   ; YES, FAILED... A0= ERROR STATUS
   21440   4601        JSR    JJJPR    ; NO, CONTINUE
   21441  20040        .TXT   "<40><40>
   21442  42111 DI
   21443  51513 SK                                                    (10)
   21444  20114  L
   21445  47507 OG
   21446  44503 IC
   21447  20117  O
   21450  45454 K,
   21451      0 "
```

```
; TAPE TEST: SWITCHES TAPE INTO TEST MODE, THEN WRITES OUT ALL BYTES FROM
; 0 THROUGH 377 INCLUSIVE, CHECKING THAT EACH BYTE IS CORRECTLY STORED AND
; RETREIVED FROM THE ON-BOARD TAPE LOOPBACK HARDWARE.

   21452   4513 TAPET:JSR    JJPK     ;
   21453      0        0               ;
   21454  20557        LDA    0,PDATA  ;
   21455  30562        LDA    2,LPAT   ;
   21456  61072        DOA    0,72     ;SWITCH ON TAPE TEST MODE
   21457  61062        DOA    0,62     ;OUTPUT DATA PATTERN TO TAPE LOOPBACK
                                       ;REGISTER
   21460  71000        DOA    2,0      ;SET DATA BUS TO 377
   21461  64461        DIA    1,61     ;READ DATA FROM TAPE LOOPBACK REGISTER
   21462 106414        SEQ    0,1      ;TEST DATA READ BACK O.K.?
   21463  63077        HALT            ;NO, FAILED! A0=SHOULD BE, A1=IS      (11)
   21464 112415        SNE    0,2      ;YES, DONE ALL PATTERNS?
   21465    403        JMP    TPASS    ;YES, EXIT TAPE TEST
   21466 101400        INC    0,0      ;NO, INCREMENT A0 ...
   21467    766        JMP    TAPET+3  ;     ... AND CONTINUE TEST WITH NEXT
                                       ;PATTERN
   21470  61073 TPASS:DOA    0,73     ;SWITCH OFF TAPE TEST MODE
   21471   4725        JSR    JJJPT    ;
   21472  20040        .TXT   "
   21473  52101 TA
   21474  50105 PE
   21475  20114  L
   21476  47507 OG
   21477  44503 IC
   21500  20117  O
   21501  45454 K,
   21502      0 "
```

```
; ASYNCHRONOUS SERIAL PORT TEST

; FIRST, DETERMINE THE NUMBER OF AVAILABLE ASYNCHRONOUS SERIAL
; PORT BOARDS.  THEN TEST EACH PORT ON EACH BOARD AS FOLLOWS:

; TURN ON THE SERIAL PORT DIAGNOSTIC LOOPBACK FEATURE AND WRITE
; OUT ALL BYTES FROM 0 THROUGH 377 INCLUSIVE TO EACH PORT IN
; TURN, CHECKING THAT EACH BYTE IS CORRECTLY RECEIVED VIA THE
; ON-BOARD LOOPBACK HARDWARE.                                           (12)

   21503   4605 MUXT: JSR    PKUP     ;SAVE ADDRESS OF LAST TEST STARTED AT
                                       ;MEMORY LOCATION 2
   21504  63077        HALT            ;
```

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---
                                        ;ISSUE PORT RESET COMMAND TO ALL
                                        ;PORTS
   21505  20530        LDA    0,PRST    ;A0=RESET PORT CONTROL WORD
   21506  24522        LDA    1,CMDO    ;A1=DOA 0,12 INSTRUCTION (WRITE PORT
                                        ;COMMAND REGISTER)
   21507  30532        LDA    2,MNPTS   ;A2=HIGHEST PORT NUMBER (TWOS
                                        ;COMPLEMENTED)
                                        ;NOTE THAT THIS IS INITIALLY SET TO -17
                                        ;(16 PORTS) BEFORE ACTUALLY PERFORMING THE
                                        ;PORT SIZING ROUTINE.
   21510   4564        JSR    CMND      ;EXECUTE RESET
                                        ;NOW, ISSUE PORT PARAMETERS (8 DATA BITS,
                                        ;EVEN PARITY, 1 STOP BIT)
   21511  20525        LDA    0,PCON    ;A0=INITIALIZE CONTROL WORD
   21512  24516        LDA    1,CMDO    ;A1=DOA 0,12 INSTRUCTION
   21513  30526        LDA    2,MNPTS   ;A2=-17 (-15 DECEMAL)
   21514   4560        JSR    CMND      ;EXECUTE PORT INITIALIZATION
   21515  61070        DOA    0,70      ;SWITCH ON SERIAL PORT LOOPBACK TEST
                                        ;MODE.  EACH PORT WILL NOW BE CAPABLE OF
                                        ;READING BACK ANY DATA SENT OUT.
   21516  20526        LDA    0,FLG3    ;FIRST PASS OF SELFTEST?
   21517 101014        SKZ    0,0       ;
   21520    526        JMP    WDATA     ;NO, SKIP PORT SIZING ROUTINE
                                        ;YES, THEN ...

; DETERMINE THE NUMBER OF AVAILABLE ASYNCHRONOUS SERIAL PORTS BY
; PERFORMING CURSORY TESTING ON EACH PORT, STARTING WITH PORT
; 16 (DECIMAL), AND WORKING DOWNWARD.  IF THE NUMBER DETERMINED
; IN THIS MANNER IS NOT 4, 8, 12, OR 16 (DECIMAL) THEN A SERIAL
; PORT BOARD HOLDS A NONFUNCTIONAL PORT AND, AS A RESULT,
; SELFTEST WILL HALT.

   21521  34513 SIZEP:LDA    3,RMASK   ;A3=1.  READ STATUS REGISTER MASK.  USED
                                        ;TO MASK OFF ALL STATUS BITS EXCEPT THE
                                        ;RECEIVE REGISTER FULL BIT
   21522 126520        SUBZL  1,1       ;
   21523  65004        DOA    1,4       ;START WITH BANK 1
   21524  20517 .SIZ1:LDA    0,C125    ;A0=125
   21525 152400        SUB    2,2       ;CLEAR ACCUMULATOR 2
   21526  50514        STA    2,WAIT    ;CLEAR WAIT
   21527  61047 WDAT: DOA    0,47      ;OUTPUT TEST DATA TO SERIAL PORT
                                        ;(INITIALLY PORT 16, BUT GETS DECREMENTED
                                        ;EACH PASS)
   21530  64446 RDSTS:DIA    1,46      ;A1=CONTENTS OF THE RECEIVER STATUS
                                        ;REGISTER (INITIALL PORT 16)
   21531 137414        AND#   1,3,SZR  ;IS THE RECEIVE DATA REGISTER FULL?
   21532    435        JMP    RDAT      ;YES, READ THE RECEIVE DATA REGISTER
   21533  10507        ISZ    WAIT      ;NO, INCREMENT THE WAIT COUNTER.  HAS IT
                                        ;BEEN BUMPED 64K TIMES?
   21534    774        JMP    RDSTS     ;NO, AGAIN CHECK THE SERIAL PORT STATUS
                                        ;REGISTER
                                        ;YES, THIS PORT IS EITHER NONEXISTENT OR
                                        ;MALFUNCTIONING.  THEREFORE, DECREMENT
                                        ;ALL I/O INSTRUCTIONS TO THE NEXT LOWER
                                        ;PORT

   21535  14772 .SIZ2:DSZ    WDAT      ;\ DECREMENT THE WRITE DATA INSTRUCTION
   21536  14771        DSZ    WDAT      ;/
   21537  14771        DSZ    RDSTS     ;\ DECREMENT THE READ STATUS INSTRUCTION
```

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---
21540  14770         DSZ     RDSTS     ;/
21541  14426         DSZ     RDAT      ;\ DECREMENT THE READ DATA INSTRUCTION
21542  14425         DSZ     RDAT      ;/
21543  10476         ISZ     MNPTS     ;DECREMENT THE HIGHEST PORT NUMBER BY ONE.
                                       ;IF DECREMENTED TO ZERO THEN HALT.
21544    760         JMP     .SIZ1     ;TEST NEXT ASYNCHRONOUS SERIAL PORT
21545 126400         SUB     1,1       ;
21546  65004         DOA     1,4       ;SELECT BANK 0
21547  10460         ISZ     BKFLG     ;DONE BANK 0?
21550    403         JMP     DOBK0     ;NO, DO BANK 0
21551  65071         DOA     1,71      ;TURN OFF MUX LOOPBACK
21552  63077         HALT              ;
21553  24451 DOBK0:  LDA     1,WRDAT   ;RESTORE DOA AND DIA INSTRUCTIONS TO
21554  44753         STA     1,WDAT    ;ORIGINAL VALUES IN PREPARATION TO TEST
21555  24450         LDA     1,RDST    ;BANK 0 PORTS.
21556  44752         STA     1,RDSTS   ;
21557  24447         LDA     1,RDDAT   ;
21560  44407         STA     1,RDAT    ;
21561  24457         LDA     1,MAXPT   ;
21562  44457         STA     1,MNPTS   ;RESTORE MNPTS ORIGINAL VALUE (177761)
21563    741         JMP     .SIZ1     ;TEST BANK 0 PORTS

21564    461 JMTBL:JMP     XMTBL     ;ELEVATOR TO MTBL (BEGINNING OF MAP TABLE)
21565    632 JJPK: JMP     JPKUP     ;ELEVATOR TO PKUP
21566    630 JJJJP:JMP     JJJPT     ;ELEVATOR TO PRINT                    (12)

21567  64447 RDAT: DIA     1,47      ;A1=THE CONTENTS OF THE RECEIVE DATA
                                       ;REGISTER
21570 106414         SEQ     0,1       ;WRITE=READ?
21571    744         JMP     .SIZ2     ;NO, THIS PORT IS EITHER NONEXISTENT OR
                                       ;MALFUNCTIONING.  TEST THE NEXT LOWER
                                       ;PORT.
21572 126400         SUB     1,1       ;
21573  65004         DOA     1,4       ;SELECT BANK 0
21574  30445         LDA     2,MNPTS   ;YES, TRANSFER THE CURRENT PORT NUMBER TO
                                       ;ACCUMULATOR 2
21575 150400         NEG     2,2       ;NEGATE THE CONTENTS OF ACCUMULATOR 2 TO
                                       ;OBTAIN A POSITIVE NUMBER
21576 151622         INCZR   2,2,SZC   ;IS A2=4, 10, 14, OR 20 (4, 8, 12, 16)?
                                       ;TEST BY DIVIDING ACCUMULATOR 2 BY 4 IN
                                       ;TWO SEPERATE STEPS.
21577  63077         HALT              ;NO, ACCUMULATOR 2 IS NOT DIVISIBLE BY 2
21600 151202         MOVR    2,2,SZC   ;YES, DIVISIBLE BY 2, DIVIDE AGAIN BY 2.
21601  63077         HALT              ;NO, ACCUMULATOR 2 IS NOT DIVISIBLE BY 4
21602 151202         MOVR    2,2,SZC   ;YES, DIVISIBLE BY 4, DIVIDE AGAIN BY 2.
21603  63077         HALT              ;NO, ACCUMULATOR 2 IS NOT DIVISIBLE BY 8
21604 151202         MOVR    2,2,SZC   ;YES, DIVISIBLE BY 8, DIVIDE AGAIN BY 2.
21605  63077         HALT              ;NO, ACCUMULATOR 2 IS NOT DIVISIBLE BY 16
21606  20421         LDA     0,BKFLG   ;YES, A2 IS DIVISIBLE BY 16 AND NOW
21607 101400         INC     0,0       ;CONTAINS "1". DETERMINE IF THE PORT IS
21610 100400         NEG     0,0       ;IN BANK 0 OR BANK 1.
21611 113000         ADD     0,2       ;A2= EITHER "1" OR "2"
21612   4403         JSR     .SIZ3     ;MODIFY THE NUMBER OF SERIAL PORTS
                                       ;AVAILABLE MESSAGE TEXT.  PERFORM A JSR
                                       ;TO LOAD ACCUMULATOR 3 WITH THE START
                                       ;OF THE MESSAGE TEXT TABLE.
21613  30466         30466             ;<61><66>  16 PORTS
21614  31462         31462             ;<63><62>  32 PORTS
21615 157000 .SIZ3:ADD     2,3       ;CALCULATE THE ADDRESS OF THE CORRECT
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                                        ;NUMBER OF PORTS TEXT FROM THE TABLE ABOVE
21616  31777        LDA    2,-1,3      ;A2=NUMBER OF SERIAL PORTS TEST
21617  50535        STA    2,POKMG+1;MODIFY "PORTS OK" MESSAGE
21620 176000        ADC    3,3         ;A3=177777
21621  54423        STA    3,FLG3      ;TRANSFER ACCUMULATOR 3 TO THE PORT SIZING
                                        ;COMPLETED FLAG
21622    424        JMP    WDATA       ;EXIT TO TEST ALL AVAILABLE SERIAL PORTS

21623    540 JMOVE:JMP    MOVE        ;ELEVATOR TO MOVE

21624  61047 WRDAT:DOA    0,47        ;
21625  64446 RDST :DIA    1,46        ;
21626  64447 RDDAT:DIA    1,47        ;
21627 177776 BKFLG:177776              ;BANK FLAG INDICATES WHICH BANK WE'RE IN
21630  61012 CMDO: DOA    0,12        ;INITIAL VALUE OF COMMAND OUT INSTRUCTION
21631  64412 STATI:DIA    1,12        ;INITIAL VALUE OF STATUS IN INSTRUCTION
21632  64413 DATI: DIA    1,13        ;INITIAL VALUE OF DATA IN INSTRUCTION
21633      0 PDATA:0                   ;DATA TO BE OUTPUT
21634      1 RMASK:1                   ;INPUT STATUS MASK (RECEIVER FULL)

21635      3 PRST: 3                   ;PORT CONTROL WORD (RESET)
21636     31 PCON: 31                  ;PORT CONTROL WORD (8 BIT, EVEN PARITY, 1
                                        ;STOP)
21637    377 LPAT: 377                 ;LAST DATA PATTERN
21640 177761 MAXPT:-17                 ;USED TO RESTORE "MNPTS"
21641 177761 MNPTS:-17                 ;COMPLEMENT OF THE MAXIMUM PORT NUMBER
21642      0 WAIT: 0                   ;
21643    125 C125: 125                 ;125 OCTAL
21644      0 FLG3: 0                   ;PORT SIZING COMPLETED FLAG

21645    566 XMTBL:JMP    MTBL        ;

21646  20765 WDATA:LDA    0,PDATA     ;
21647  10761        ISZ    CMDO        ;MODIFY DOA INSTRUCTION TO ACCESS PORT
21650  24760        LDA    1,CMDO      ;WRITE DATA REGISTER.
21651  30770        LDA    2,MNPTS     ;
21652   4422        JSR    CMND        ;WRITE THE DATA REGISTER OF EACH PORT.
21653  14755        DSZ    CMDO        ;RESTORE DOA INSTRUCTION.


21654  24756 TEST: LDA    1,DATI
21655  44441        STA    1,RDATA
21656  24753        LDA    1,STATI
21657  44405        STA    1,RSTAT
21660  30761        LDA    2,MNPTS
21661  34753        LDA    3,RMASK
21662 126400        SUB    1,1
21663  44757        STA    1,WAIT
21664  64412 RSTAT:DIA    1,12        ;***** GETS MODIFIED BY PROGRAM *****
21665 137415        AND#   1,3,SNR
21666    402        JMP    .WAIT
21667    427        JMP    RDATA

21670  10752 .WAIT:ISZ    WAIT        ;TIMED OUT ?
21671    773        JMP    RSTAT       ; NO, CONTINUE
21672  61071        DOA    0,71        ;SWITCH OFF MUX TEST MODE
21673  63077        HALT   ; YES, TIMED OUT !

21674  44401 CMND: STA    1,CMND+1 ;A0=COMMAND, A1= INSTRUCTION, A2=MINUS
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(12)

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---
                                        ;NUMBER OF PORTS
21675  61012        DOA     0,12        ;***** GETS MODIFIED BY PROGRAM *****
21676  10777        ISZ     CMND+1      ;MODIFY INSTRUCTION
21677  10776        ISZ     CMND+1      ;TO ADDRESS NEXT PORT
21700 151404        INC     2,2,SZR     ;FINISHED ALL PORTS?
21701    774        JMP     CMND+1      ;NO ,CONTINUE
21702  10725        ISZ     BKFLG       ;DONE BANK 1 YET?
21703    406        JMP     DOBK1       ;NO, DO BANK 1
21704 126400        SUB     1,1         ;YES, SELECT BANK 0 AND MOVE ON
21705  65004        DOA     1,4         ;
21706 126120        ADCZL   1,1         ;GENERATE 177776
21707  44720        STA     1,BKFLG     ;RESTORE BANK INDICATOR FLAG
21710   1400        JMP     0,3         ;RETURN
21711 126520 DOBK1:SUBZL    1,1         ;GENERATE ONE
21712  65004        DOA     1,4         ;SELECT BANK 1
21713  24715        LDA     1,CMDO      ;REINITIALIZE COMMAND
21714  30725        LDA     2,MNPTS     ;REINITIALIZE MAXIMUM PORT NUMBER
21715    757        JMP     CMND        ;

21716  64413 RDATA:DIA     1,13        ;***** GETS MODIFIED BY PROGRAM *****
21717 106414        SEQ     0,1         ;CHECK LOOPBACK DATA
21720  63077        HALT    ;FAILED ! A0 = SHOULD BE, A1 = IS
21721  10743        ISZ     RSTAT       ;MODIFY INSTRUCTION ...
21722  10742        ISZ     RSTAT       ; ... TO ADDRESS NEXT PORT
21723  10773        ISZ     RDATA       ;MODIFY INSTRUCTION ...
21724  10772        ISZ     RDATA       ; ... TO ADDRESS NEXT PORT
21725 151404        INC     2,2,SZR     ;DONE ALL PORTS ?                    (12)
21726    736        JMP     RSTAT       ; NO, TEST NEXT PORT
21727  10700        ISZ     BKFLG       ;DONE BANK 1?
21730    412        JMP     BANK1       ;NO, DO BANK 1
21731 126400        SUB     1,1         ;YES, WE HAVE DONE BOTH BANKS
21732  65004        DOA     1,4         ;SELECT BANK 0
21733 126120 RLOOP:ADCZL    1,1         ;GENERATE 177776
21734  44673        STA     1,BKFLG     ;RESTORE BANK INDICATOR FLAG
21735  24702        LDA     1,LPAT      ; YES, MOVE ON TO NEXT DATA PATTERN
21736 106415        SNE     0,1         ;DONE 0 THROUGH 377 PATTERNS ?
21737    412        JMP     MXEND       ; YES, EXIT
21740 101400        INC     0,0         ; NO, INCREMENT (A0) TO NEXT PATTERN ...
21741    706        JMP     WDATA+1     ; ... AND CONTINUE

21742  24412 BANK1:LDA     1,POKMG+1;A1 = "16" OR "32" PORTS.
21743  30651        LDA     2,.SIZ3-1;A2 = "32"
21744 132414        SEQ     1,2         ;
21745    766        JMP     RLOOP       ;
21746 126520        SUBZL   1,1         ;GENERATE 1
21747  65004        DOA     1,4         ;SELECT BANK 1
21750    704        JMP     TEST        ;
21751  61071 MXEND:DOA     0,71        ;SWITCH OFF MUX TEST

21752   4614        JSR     JJJP        ;
21753  20040 POKMG:.TXT    "<40><40>
21754  20040 <40><40>
21755  20120 <40>P
21756  47522 OR
21757  52123 TS
21760  20117  O
21761  45456 K.
21762      0 "
```

```
;MOVE SELFTEST THROUGH CORE AND REPEAT

21763   4602 MOVE: JSR    JJPK      ;*** GETS MODIFIED TO SKIP MOVE ROUTINE IF
                                     ;EITHER POWER-UP OR POWER-UP/IPL FLAGS ARE
                                     ;SET***
21764 130406       -DIST*2           ;TENT. ASSUME DOUBLE MOVE REQUIRED
21765  20425       LDA    0,R.MIN
21766  24425       LDA    1,R.MAX
21767 162433       SLE    3,0       ;IS SELF WHERE SINGLE MOVE WOULD
21770 166033       SLS    3,1       ;    CAUSE STRADDLING WORDS 0-3 ?
21771 151240       MOVOR  2,2       ;  NO, THEN DO SINGLE MOVE
21772  21602       LDA    0,TOPWD-REF2,3
21773  24421       LDA    1,R.OFS
21774 136400       SUB    1,3       ;A3 = CURRENT LOC. OF SELF
21775 173000       ADD    3,2
21776 113400       AND    0,2       ;A2 = NEW LOCATION OF SELF
21777  24416       LDA    1,NWRDS   ;
22000  21400 MOVLP:LDA    0,0,3     ;NOW DO THE MOVE LOOP
22001  41000       STA    0,0,2
22002 175400       INC    3,3
22003 151400       INC    2,2
22004 125404       INC    1,1,SZR   ;MOVE DONE ?
22005    773       JMP    MOVLP     ;  NO
22006  24407       LDA    1,NWRDS   ;
22007 133000       ADD    1,2
22010  50000       STA    2,0       ;FOR EASILY FINDING SELF WHEN MOVED
22011   1000       JMP    0,2                                          (13)

22012  22653 R.MIN: DIST-END-200+REF2-1;
22013  25114 R.MAX: DIST+REF2-L.SELF+4;
22014   1313 R.OFS: REF2-L.SELF     ;
22015 175544 NWRDS:L.SELF-END-200   ;

22016  34413 EXIT1:LDA    3,MBEG1   ;
22017    403       JMP    EXIT      ;

22020  62677 EXIT2:IORST            ;POWER-UP/IPL
22021  34411       LDA    3,MBEG2   ;

22022  20404 EXIT: LDA    0,MOFST   ;
22023  24404       LDA    1,MNWDS   ;
22024  30404       LDA    2,MSTRT   ;
22025  60077       NIO    77        ;

22026      0 MOFST:0                ;
22027   1000 MNWDS:1000             ;
22030  77000 MSTRT:A.MANIP          ;
22031  77005 MBEG1:A.MANIP+MANP5-L.MANIP
22032  77006 MBEG2:A.MANIP+MANP6-L.MANIP

22033   5400 MTBL: JSR    0,3       ;PICKUP LAST ADDRESS + 1 (BEGIN MEMORY
                                     ;MAP TABLE)

       23575 DIST=23575
       22034 END=.

                   .EOT              ;SELFTEST
```

Section 2
MANIP

MANIP is a software program that enables an operator to manipulate the operations of the central processing unit (CPU) from the master terminal.

This section contains the following information and instructions on MANIP:

- Accessing MANIP
- MANIP Command Descriptions
- MARK 2E MANIP Listing
- MARK 4 MANIP Listing
- MARK 4E MANIP Listing

2.1 ACCESSING MANIP

To access MANIP, turn the power ON. The MANIP menu is displayed as follows:

```
                                                    444     4
POINT 4 Data Corporation                          4444      444
MARK 2E [4/4E]                                  444   4     4444
                                                4   444     4444


ENTER COMMAND LETTER                          44444444      4444
(PLUS OPERAND(S) WHERE APPROPRIATE)             444444      444
FOLLOWED BY A CARRIAGE RETURN                     4444      4


A = DISPLAY CONTENTS OF ACCUMULATORS
C = CHANGE ACCUMULATOR CONTENTS
D = DISPLAY CONTENTS OF MEMORY
F = BOOT FROM FLOPPY DISK
H = LOAD PROGRAM FROM STREAMER TAPE
J = JUMP WITH ACCUMULATORS AND CARRY RESTORED
K = STORE CONSTANT IN BLOCK OF MEMORY
M = MOVE A BLOCK OF MEMORY
P = PROGRAM LOAD (BOOT) FROM HARD DISK
V = LOAD (@ 20000) AND RUN HARDWARE VERIFY TEST
: = OPEN SPECIFIC LOCATION TO EXAMINE OR STORE
@ = LOAD DBUG AT 73000
? = DISPLAY THIS MENU
-> P
```

The MANIP commands and parameters are described in Section 2.2.

2.2 MANIP COMMAND DESCRIPTIONS

To use MANIP, a command and command parameters (where required) must be entered on the master terminal keyboard. A command consists of a single letter (the command identifier) and parameters that specify addressing modes, memory addresses and data input. All parameters must be entered in octal. The letters x, y and z are used to represent octal parameters.

If an error is made while entering a command, correct it by using one of the following:

1. Press <ESC> or any other control character except <RETURN> to delete the entry and then enter the command again.

2. If an error is made when entering an octal value, enter several zeros and then the correct octal number. Only the last six octal digits will be used.

TABLE 2-1. MANIP COMMANDS (1 of 3)

Command & Parameters	Definition
A	Displays on the master terminal the program counter, the contents of accumulators A0, A1, A2, A3, and the carry flip-flop as they were at the time MANIP was entered.
Cx,y	Changes accumulator or carry flip-flop: • If x is 0, 1, 2, or 3, then y is stored as saved value for accumulator x (A0, A1, A2, A3, respectively). • If x is 4, then saved value of the carry flip-flop is set equal to the LSB of y. • Parameter description x - 1 octal digit 0-4 y - 1 word octal
Dx	Dump memory in octal, beginning at location x. Eight words are displayed per line, with the address of the first word at the beginning of each line. • Parameter Description x - octal number representing a 16-bit memory address
F	Reads block 0 from floppy disk and idles at 377 waiting to be overwritten by DMA from floppy disk.
H	Reads block 0 of a 45MB (QIC-24) tape and idles at 377 waiting to be overwritten by DMA from tape.
H46	Reads block 0 of a 20MB (QIC-11) tape. Following an H46 command, the drive cannot read 45MB (QIC-24) tapes until a tape RESET command is issued or the power has been turned OFF and ON.

TABLE 2-1. MANIP COMMANDS (2 of 3)

Command & Parameters	Definition
Jx	Jump to location x after restoring accumulator and carry values. • Parameter Description x - octal number representing 16-bit memory address
Kx,y,z	Store the octal constant z in locations x through y, inclusive. • Parameter Description x - octal number representing 16-bit beginning memory address y - octal number representing 16-bit ending memory address z - octal number representing constant
Mx,y,z	Move block in memory. Locations x through y, inclusive, are moved to area starting at location z. • Source and destination areas may overlap in either direction without bad effects. • May be used to move MANIP itself as long as destination area does not overlap source area. • Parameter Description x - octal number representing 16-bit beginning memory address y - octal number representing 16-bit ending memory address z - octal number representing 16-bit beginning memory address of new location
P	Initial Program Load from disk (Sector 0, Surface 0, Cylinder 0). Performs standard bootstrap APL function (i.e., starts DMA action and then idles at location 377 waiting for the disk to overwrite that location).

TABLE 2-1. MANIP COMMANDS (3 of 3)

Command & Parameters	Definition
V	Loads self-test at location 20000 and runs hardware verify test. Upon successful completion, one of the following is displayed on the master terminal: MARK 2E CPU SELFTEST REV nn CPU OK, MAP OK, nnMB MEMORY OK, DISK LOGIC OK, TAPE LOGIC OK, nPorts OK MARK 4 SELFTEST... CPU OK, MAP OK, nMB MEMORY OK, MUX OK, TAPE LOGIC OK, DISK LOGIC OK. MARK 4E SELFTEST REV. n.n CPU OK, MAP OK, nMB MEMORY OK, TAPE LOGIC OK, nnPORTS OK Self-test then moves itself to another memory location and repeats the above. Main memory will be overwritten.
x:y	Octal value y is stored at location x, and next cell is opened. • Parameter Description x - octal number representing 16-bit memory address y - 1 to 6 digits representing an octal value If y is omitted, the current content of location x is displayed. A new y may then be entered, or the next cell opened without change.
@	Loads DBUG at location 73000; main memory will be overwritten.

2.3 MARK 2E MANIP LISTING

This section contains the MANIP listing for the MARK 2E.

MARK 2E MANIP LISTING (1 of 11)

```
JUN  1, 1987  17:00:29
;*****************************************************************
;POINT 4 DATA CORPORATION MARK 2E MANIP PROGRAM
;MANIP -- RELOCATABLE RAM MANIPULATOR AND DEBUGGER
;EDITED FOR THE MARK 2E BY BOB WARD
;INITIAL RELEASE DECEMBER, 1986 - LAST EDITED APRIL 15, 1987
;1/09/87 - MODIFICATIONS FOR DELETION OF FRONT PANEL KEYSWITCH -
;          "ON" ENTRY POINT JUMPS TO "AUTO" ENTRY POINT
;4/15/87 - MODIFICATIONS FOR DELETION OF AUTOMATIC LOAD AND
;          EXECUTE OF SELFTEST PRIOR TO AUTO IPL
;6/01/87 - MODIFICATIONS FOR SEPRATION OF "ON" AND "AUTO" ENTRY
;          POINTS WITH "ON" ENTRY PERFORMING AS IN PRIOR RELEASE
;          AND "AUTO" ENTRY CALLING THE MANIP "V" COMMAND
;*****************************************************************

;                All Rights Reserved
;     Copyright (C) 1975, Educational Data Systems
;     Copyright (C) 1987, Point 4 Data Corporation
;

          17000 L.ASM=        17000    ;ASSEMBLY LOCATION (ARBITRARY)
                                       ;17000 IS USED SO THAT SELFTEST STARTS AT
                                       ;20000

          17000 L.MANIP=      0+L.ASM  ;MANIP (MANIP IS PLACED AT LOC. 0 IN
                                       ;EPROM)
          20000 L.SELF=       1000+L.ASM;SELFTEST (@ LOCATION 1000 IN EPROM)
          22000 L.MENU=       3000+L.ASM;MENU TEXT (@ LOCATION 3000 IN EPROM)
          24000 L.DBUG=       5000+L.ASM;DBUG (@ LOCATION 5000 IN EPROM)
          27400 L.BZUD=       10400+L.ASM;BZUD FOR WD CONTROLLER (@ LOCATION
                                        ;10400 IN EPROM)

          77000 A.MANIP=      77000    ;CORE ADDRESS FOR MANIP
          20000 A.SELF=       20000    ;CORE ADDRESS FOR SELFTEST
          73000 A.DBUG=       73000    ;CORE ADDRESS FOR DBUG

          17000 .LOC  L.MANIP          ;ACTUAL LOCATION IS 77000

             12 P1S=  12               ;PORT 1 STATUS/COMMAND REGISTER
             13 P1D=  13               ;PORT 1 DATA REGISTER
             10 TTY=  10               ;PORT 0 STATUS/COMMAND REGISTER

   17000  77000 PC:   77000            ;INITIAL PROGRAM COUNTER SAVED HERE

; ON ENTRY TO EACH OF THE "COMMAND LETTER" PROCEDURES,
;      A0 = FIRST OPERAND
;      A1 = SECOND OPERAND
;      A2 = FIRST OPERAND AS AN ADDRESS
;      A3 = B = CENTRAL REFERENCE POINT

;MANIP ENTRY POINTS:

   17001    442 MANP1:JMP    MANIP    ;HALT OR RESET ENTRY POINT
   17002    441 MANP2:JMP    MANIP    ;RESERVED ... NOT CURRENTLY USED
   17003    422 MANP3:JMP    MNP3A    ;POWER-UP "ON" ENTRY POINT (FRONT PANEL
                                      ;SWITCH = ON).  THIS HAS BEEN MODIFIED TO
                                      ;PERFORM AN AUTO IPL SINCE THE FRONT
                                      ;PANEL SWITCH HAS BEEN REMOVED
   17004    435 MANP4:JMP    MNP4A    ;POWER-UP "AUTO" ENTRY POINT (FRONT PANEL
                                      ;SWITCH = AUTO).  THIS HAS BEEN MODIFIED TO
```

```
---
                                        ;CALL ".V" (SELFTEST) FOR USE BY OPERATIONS

;SERIAL PORT COMMAND REGISTER INITIALIZATION

   17005  20515 SPORT:LDA    0,RESET  ;LOAD A0 WITH INITIALIZATION WORD
   17006  61046        DOA    0,TTY+36 ;BEGIN WITH PORT #16
   17007  24777        LDA    1,.-1    ;
   17010  44403        STA    1,.+3    ;STORE DOA INSTRUCTION FOR MODIFICATION

   17011  14402 SPRT1:DSZ    .+2      ;DECREMENT DOA INSTRUCTION DEVICE CODE
   17012  14401        DSZ    .+1      ;BY 2 EACH TIME,
   17013  61046        DOA    0,TTY+36 ;THEN ISSUE COMMAND AGAIN.  (THIS LOCATION
                                        ;GETS MODIFIED EACH PASS)
   17014  24777        LDA    1,.-1    ;GET CURRENT DOA INSTRUCTION
   17015  30404        LDA    2,.+4    ;GET DOA INSTRUCTION FOR LAST PORT (TTY)
   17016 132414        SEQ    1,2      ;ALL PORTS INITIALIZED ?
   17017    772        JMP    SPRT1    ;NO, INITIALIZE REMAINING PORTS
   17020  20503        LDA    0,BMODE  ;YES, NOW SET UP PORTS 0 AND 1
   17021  61010        DOA    0,TTY    ;
   17022  61012        DOA    0,TTY+2  ;
   17023    563        JMP    RTN1     ;RETURN

   17024      0 PWRUP:0               ;INITIAL POWER-UP FLAG

;MANIP POWER-UP ROUTINE

   17025   4760 MNP3A:JSR    SPORT    ;INITIALIZE ALL SERIAL PORTS
   17026 102000        ADC    0,0      ;A0 = 177777
   17027  40775        STA    0,PWRUP  ;SET INITIAL POWER-UP FLAG
   17030    446        JMP    .QRY     ;PRINT HELP MENU
   17031   4555 MNP3B:JSR    RTN1     ;A3 = .B
   17032   5415        JSR    TCRLF-B,3;TYPE CARRIAGE RETURN AND LINE FEED
   17033   5444        JSR    TYPE-B,3 ;TYPE "->"
   17034  37055        ">*L+"-         ;
   17035   5444        JSR    TYPE-B,3 ;TYPE "P
   17036    120        "P              ;
   17037 102400        SUB    0,0      ;FORCE DRIVE NUMBER=0 FOR POWER UP IPL
   17040    571        JMP    JJP      ;JUMP TO .P0

   17041   4744 MNP4A:JSR SPORT        ;INITIALIZE ALL SERIAL PORTS
   17042    570        JMP    JJV      ;JUMP TO .V

;MAIN MANIP PROGRAM

   17043  40467 MANIP:STA    0,A      ;WITH PREAMBLE COMPLETE, START MANIP HERE
   17044  44467        STA    1,A+1    ;SAVE ACCUMULATORS AND CARRY
   17045  50467        STA    2,A+2
   17046  54467        STA    3,A+3
   17047 102560        SUBCL  0,0
   17050  40466        STA    0,A+4
   17051   4734        JSR    SPORT
   17052   5444        JSR    TYPE-B,3 ;OUTPUT TWO BELLS
   17053   3407        7*L+7
   17054   5415        JSR    TCRLF-B,3;TYPE CR

   17055  24723 .A:    LDA    1,PC     ;"A" = DUMP PC AND ACCUMLATORS
   17056   5422        JSR    TPOCT-B,3
   17057   5446        JSR    TPCLN-B,3
   17060  24452        LDA    1,A
```

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---
17061   5422        JSR     TPOCT-B,3
17062  24451        LDA     1,A+1
17063   5422        JSR     TPOCT-B,3
17064  24450        LDA     1,A+2
17065   5422        JSR     TPOCT-B,3
17066  24447        LDA     1,A+3
17067   5422        JSR     TPOCT-B,3
17070  24446        LDA     1,A+4     ;AND CARRY
17071   5422 TOCTI:JSR     TPOCT-B,3
17072    401        JMP     INCM1

17073    543 INCM1:JMP     INCMD
17074      0 PRMA: 0
17075   3000 QMPTR:L.MENU-L.ASM

17076  20777 .QRY: LDA     0,QMPTR   ;"?" = PRINT MENU TEXT FROM APL PROM
17077  40775        STA     0,PRMA    ;A0=INITIAL POINTER INTO MENU TEXT
17100  20774 QLOOP:LDA     0,PRMA    ;
17101 126520        SUBZL   1,1       ;A1=1 (NUMBER OF WORDS TO READ FROM PROM)
17102   4402        JSR     .+2       ;JSR LOADS A3 WITH NEXT ADDRESS
17103      0        0                 ;2 BYTES OF TEXT READ FROM PROM ARE PLACED
                                      ;HERE
17104 171000        MOV     3,2       ;A3=A2=PREVIOUS ADDRESS
17105   4402        JSR     PMCT      ;JSR LOAD A3 WITH ADDRESS OF NIO 77 INSTR
17106  60077        NIO     77        ;WITH ACCUMULATORS SETUP, READ TEXT FROM
                                      ;PROM
17107   5400 PMCT: JSR     0,3       ;JUMP TO NIO 77 INSTRUCTION WHILE STORING
                                      ;NEXT ADDRESS IN A3
17110  20773        LDA     0,.-5     ;A0=WORD OF MENU TEXT JUST READ FROM PROM
17111 101015        SNZ     0,0       ;ARE BOTH BYTES OF MENU TEXT = 0?
17112    404        JMP     .QEND     ;YES, QUIT READING TEXT FROM PROM
17113   4515        JSR     JTP2C     ;NO, PRINT 2 CHARACTERS AND FETCH NEXT 2
17114  10760        ISZ     PRMA      ;INCREMENT POINTER INTO MENU TEXT
17115    763        JMP     QLOOP     ;
17116  20706 .QEND:LDA     0,PWRUP   ;LOAD A0 WITH POWER-UP FLAG
17117 101015        SNZ     0,0       ;INITIAL POWER-UP?
17120    516        JMP     INCMD     ;NO
17121    710        JMP     MNP3B     ;YES

17122      3 RESET:3                 ;SOFTWARE RESET FOR UARTS, ALSO USED AS A
                                      ;CONSTANT
17123     11 BMODE:11                ;7 DATA BITS, 1 STOP, EVEN PAR, INTS OFF
17124      7 C7:   7
17125    177 C177: 177
17126      4 C4:   4
17127     60 C60:  60
17130     20 C20:  20
17131      5 C5:   5

17132      5 A:    .BLK    5         ;SAVE STATUS FOR CPU HERE

17137  30772 .C:   LDA     2,C5      ;"C" = CHANGE ACCUMULATOR, C
17140 142432        SGR     2,0       ;IS FIRST OPND <= 4 ?
17141   1703 .CREF:JMP     ABORT-B,3

17142 117000 .C1:  ADD     0,3
17143  45601        STA     1,A-B,3   ;SAVE 2D OPND AS NEW CPU STATUS
17144    472        JMP     INCMD
```

```
---
   17145  20771 .J:   LDA    0,A+4     ;"J" =JUMP; LOAD ACCUMULATORS
   17146 101200       MOVR   0,0       ;  AND CARRY
   17147  20763       LDA    0,A
   17150  24763       LDA    1,A+1
   17151  30763       LDA    2,A+2
   17152  34763       LDA    3,A+3
   17153   2556       JMP    @OP1      ;JUMP TO USER PROGRAM

   17154  21402 .K:   LDA    0,OP3-B,3;"K" = ENTER A CONSTANT IN CORE
   17155  41000       STA    0,0,2
   17156 151400       INC    2,2
   17157  11407       ISZ    COUNT-B,3
   17160    775       JMP    .-3
   17161   1705       JMP    INCMD-B,3

   17162 106400 .M:   SUB    0,1       ;MOVE A BLOCK OF WORDS
   17163  35402       LDA    3,OP3-B,3;GET THE DESTINATION STARTING ADDRESS
   17164 102520       SUBZL  0,0
   17165 156033       SLS    2,3       ;IS SOURCE END < DESTINATION START ?
   17166    404       JMP    .M1       ;YES, DO A FORWARD MOVE
   17167 102000       ADC    0,0
   17170 133000       ADD    1,2
   17171 137000       ADD    1,3
   17172  25000 .M1:  LDA    1,0,2
   17173  45400       STA    1,0,3
   17174 113000       ADD    0,2
   17175 117000       ADD    0,3
   17176  10542       ISZ    COUNT
   17177    773       JMP    .M1
   17200    436       JMP    INCMD

; BRANCH.  BRANCHES TO THE DESTINATION INDICATED IN TABLE ENTRY IF THE
; RIGHT-MOST 7 (OR 5) BITS THEREOF AGREE WITH A0.  CALLING SEQUENCE:
;     JSR    BRNC7    (OR BRNC5 FOR 5-BIT, WITH A1 = 37)
;     DEST1-.-1*K+CHAR1(OR F INSTEAD OF K FOR 5-BIT)
;     DEST2-.-1*K+CHAR2
;       ...
;     END OF LIST IS INDICATED BY 7 (OR 5) LSB'S = 0

; A -1 IN THE TABLE IS USED TO DETERMINE MAX ALLOWABLE NO. OF OPERANDS

   17201  24724 BRNC7:LDA    1,C177
   17202 123400 BRNC5:AND    1,0
   17203  31400       LDA    2,0,3
   17204 175400       INC    3,3
   17205 147415       AND#   2,1,SNR   ;END OF LIST ?
   17206    522 RTN1: JMP    RTNA3     ;  YES
   17207 150015       COM#   2,2,SNR   ;IS LIST ENTRY = -1 ?
   17210  10526       ISZ    N.OP      ;  YES: MAX. NO. OPNDS. EXCEEDED ?
   17211 112421       SUBZ   0,2,SKP   ;  NO OR YES,NO
   17212    422       JMP    ABORT     ;  YES,YES
   17213 133414       AND#   1,2,SZR   ;MATCH ?
   17214    767       JMP    BRNC5+1   ;  NO
   17215 151113       SSN    2,2       ;IS DISPLACEMENT NEGATIVE ?
   17216 125620       INCZR  1,1       ;  NO - CHANGE A1 TO 100 (OR 20)
   17217 151200       MOVR   2,2
   17220 125224       MOVZR  1,1,SZR   ;SHIFTED 7 (OR 5) PLACES ?
   17221    776       JMP    .-2       ;  NO
   17222  20507       LDA    0,OP1
```

```
---
   17223  24507        LDA    1,OP2
   17224 157000        ADD    2,3
   17225 111000        MOV    0,2
   17226    502        JMP    RTNA3

   17227 177767 N.TS: B-TSEND;NO. TS CELLS TO BE CLEARED FOR NEW CMD

   17230    550 JTP2C:JMP    TP2CH
   17231    567 JJP:  JMP    JP        ;ELEVATOR TO .P0
   17232    567 JJV:  JMP    JV        ;ELEVATOR TO .V



- PAGE 2 -
   17233  60411        DIA    0,TTY+1
   17234   4541 ABORT:JSR    TYPE
   17235    134        "\
   17236   4510 INCMD:JSR    TCRLF     ;TYPE CR, LF
   17237   4536        JSR    TYPE      ;TYPE PROMPT
   17240  37055        ">*L+"-
   17241  54501        STA    3,.TS     ;INITIALIZE OPERAND STORAGE POINTER
   17242  14500        DSZ    .TS
   17243  24764        LDA    1,N.TS
   17244 102400        SUB    0,0
   17245  41400        STA    0,0,3     ;CLEAR TEMP STORE AREA
   17246 175400        INC    3,3
   17247 125404        INC    1,1,SZR
   17250    775        JMP    .-3
   17251  60410 INCHA:DIA    0,TTY     ;GET PORT 0 STATUS
   17252 125400        INC    1,1       ;BLINK THE CARRY
   17253 101213        SKO    0,0
   17254    775        JMP    INCHA     ;NO, STAY IN LOOP
   17255  60411        DIA    0,TTY+1   ;GET THE DATA WORD
   17256   4723        JSR    BRNC7     ;SEE IF IT'S AN ACTIVE CHARACTER
                       ;
   17257  30415        .CR-.-1*K+15     ;CARRIAGE RETURN
   17260  40336        .UP-.-1*K+"^     ;UP ARROW (EXAMINE PREVIOUS)
   17261 172433        ABORT-.-1*K+33
                       ;
   17262  20000 C20K: 20000            ;SERVES AS LIST TERMINATOR
                       ;
   17263  30467        LDA    2,C40
   17264 112032        SGE    0,2       ;IS IT A CNTRL CHAR ?
   17265    747        JMP    ABORT     ;YES, ABORT
   17266  61011        DOA    0,TTY+1   ;NOT ACTIVE, ECHO IT
   17267  30640        LDA    2,C60
   17270 142400        SUB    2,0
   17271  34633        LDA    3,C7
   17272 116432        SGR    0,3       ;IS IT AN OCTAL DIGIT ?
   17273    404        JMP    OCTAL     ;  YES
   17274 143023        ADDZ   2,0,SNC   ;RECONSTITUTE CHAR.; IS IT COMMA ?
   17275  40437 INCH2:STA    0,T       ;  NO, SAVE IT
   17276    412        JMP    SOCTF

   17277  10436 OCTAL:ISZ    OCTFL     ;FIRST OCTAL DIGIT OF A NUMBER ?
   17300  10442        ISZ    .TS       ;  YES, ADVANCE PARAMETER POINTER
   17301  26441        LDA    1,@.TS    ;PROCESS OCTAL CHARACTER
   17302 125120        MOVZL  1,1       ;SHIFT PREV. NO. LEFT 3 BITS
   17303 125120        MOVZL  1,1
   17304 125120        MOVZL  1,1
   17305 107000        ADD    0,1       ;ADD NEW DIGIT TO PREV. NO.
   17306  46434        STA    1,@.TS
   17307 102000        ADC    0,0
   17310  40425 SOCTF:STA    0,OCTFL   ;SET OCTAL FLAG
   17311    740        JMP    INCHA
```

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---
17357   4422        JSR    TPCHA     ;  TYPING THE CHARACTER IN A0
17360 102620 TPA01:SUBZR   0,0       ;PREPARE TO MOVE MSB OF A1 INTO A0
17361 101041        MOVO   0,0,SKP   ;SET CARRY TO FORM "PUSHER" BIT
17362  20700 TPNXT:LDA    0,C20K    ;LEFT-SHIFT ONE DIGIT FROM A1 INTO A0
17363 125105        MOVL   1,1,SNR   ;INITIALLY INSERTS "PUSHER" BIT
17364    743        JMP    RTNTS     ;EXIT WHEN "PUSHER" BIT IS GONE
17365 101103        MOVL   0,0,SNC
17366    775        JMP    .-3
17367 101015        SNZ    0,0       ;NON-ZERO DIGIT  ...
17370 125135        MOVZL# 1,1,SNR   ;  ... OR LAST DIGIT ?
17371  30754        LDA    2,K60;  YES: ADDEND FOR ASCII DIGIT
17372 143040        ADDO   2,0
17373   4406        JSR    TPCHA
17374    766        JMP    TPNXT

17375  21400 TYPE: LDA    0,0,3     ;TYPE THE CHAR.(S) FOLL. THE JSR
17376 175401        INC    3,3,SKP
17377  20417 TPCLN:LDA    0,COLON   ;TYPE COLON
17400 101020 TP2CH:MOVZ   0,0       ;TYPE 2 CHARACTERS IN A0
17401  54454 TPCHA:STA    3,RTNTP
17402  74410 T1:   DIA    3,TTY     ;GET PORT 0 STATUS
17403 175202        MOVR   3,3,SZC   ;IS ANYTHING IN REC REG?
17404    627        JMP    ABORT-1   ; YES, ABORT
17405 175213        SKO    3,3       ;IS TRANSMIT REG EMPTY?
17406 175101        MOVL   3,3,SKP   ;RESTORE CARRY IF NO SKIP
17407 175101        MOVL   3,3,SKP   ;RESTORE CARRY IF SKIP
17410    772        JMP    .-6       ; NO, STAY IN LOOP
17411  34444        LDA    3,RTNTP
17412  61011 T2:   DOA    0,TTY+1
17413 101362 TPCH2:MOVCS  0,0,SZC   ;SECOND CHAR. TO BE TYPED ?
17414    765        JMP    TPCHA     ;  YES
17415    713        JMP    RTNA3

17416     72 COLON:":

17417    617 IN1:  JMP    INCMD

17420    514 JP:   JMP    .P        ;ELEVATOR TO .P0
17421    472 JV:   JMP    .V+1      ;ELEVATOR TO SELFTEST

17422 122000 .CR:  ADC    1,0       ;PROCESS CARRIAGE RETURN
17423  41407       STA    0,COUNT-B,3
17424  20716       LDA    0,.TS
17425  24716       LDA    1,K3
17426 122400       SUB    1,0
17427 162422       SUBZ   3,0,SZC   ;> 3 OPERANDS ENTERED ?
17430   1703       JMP    ABORT-B,3;  YES, ERROR
17431  40705       STA    0,N.OP    ;NO. OF OPERANDS - 5
17432  20702       LDA    0,T       ;BRANCH ON INITIAL LETTER
17433   5650       JSR    BRNC7-B,3;COMMAND LETTER BRANCH TABLE
                   ;                ;MAX 3 OPERANDS
17434 123713       .K-.-1*K+"K
17435 125115       .M-.-1*K+"M
17436  15500       .LOAD-.-1*K+"@
17437 177777              -1        ;MAX 2 OPERANDS HEREAFTER
17440  16720       .P-.-1*K+"P
17441 117303       .C-.-1*K+"C
17442   2672       .CLN-.-1*K+":
17443 151504       .D-.-1*K+"D
```

```
---
17444 177777                -1        ;MAX 1 OPERAND HEREAFTER
17445 101701         .A-.-1*K+"A
17446 117512         .J-.-1*K+"J
17447  10526         .V-.-1*K+"V
17450  14510         .H-.-1*K+"H
17451  14106         .F-.-1*K+"F
17452 104677         .QRY-.-1*K+"?
                     ;
17453 177400 K377L:177400          ;SERVES AS LIST TERMINATOR
17454   1703         JMP     ABORT-B,3

17455  77377 RTNTP:VAR.    ;RETURN ADDRESS USED BY TPCHA

17456  11405 .CLN: ISZ     N.OP-B,3 ;INPUT = COLON: TWO OPERANDS ?
17457    417         JMP     .CLN1    ;  NO, DISPLAY CONTENT
17460  45000         STA     1,0,2    ;  YES, STORE OP2 AT ADR1
17461 102521 .CLN2:SUBZL  0,0,SKP  ;<< FROM .CLN1
17462 102000 .UP:   ADC     0,0      ;"^" = EXAMINE PREVIOUS ADDRESS
17463  25400         LDA     1,OP1-B,3
17464 107000         ADD     0,1
17465  45400         STA     1,OP1-B,3
17466   5415 NXTL: JSR     TCRLF-B,3
17467  25400         LDA     1,OP1-B,3
17470   5422         JSR     TPOCT-B,3
17471  45410         STA     1,FLAG-B,3;SET "EXAMINE" FLAG = 0
17472  45401 .CLN3:STA     1,OP2-B,3;PREPARE FOR OCTAL INPUT --> OP2
17473  55411         STA     3,.TS-B,3;(PRETEND ONE OPERAND HAS COME IN)
17474   5446         JSR     TPCLN-B,3;TYPE A COLON
17475   1744         JMP     INCH2-B,3;COUNT AS ONE OPERAND, SET T = ":"

17476  21410 .CLN1:LDA     0,FLAG-B,3;2D OPERAND NOT TYPED IN
17477 101014         SKZ     0,0      ;HAVE WE ALREADY EXAMINED IT ?
17500    761         JMP     .CLN2    ;  YES, GO TO NEXT LINE
17501  11410         ISZ     FLAG-B,3 ;  NO
17502  25000         LDA     1,0,2
17503   5423         JSR     TPOCL-B,3;TYPE THE VALUE AT OP1
17504    766         JMP     .CLN3    ;TYPE A COLON & WAIT FOR INPUT

17505    641 TYPCR:JMP     TCRLF

17506   1000 VOFST:1000
17507   2000 VNWDS:2000
17510  20000 VSTRT:20000  ;LITERAL OFFSET INTO SELF TEST
17511  20000 VADDR:20000
17512   4773 .V:    JSR     TYPCR
17513  20773         LDA     0,VOFST
17514  24773         LDA     1,VNWDS
17515  30773         LDA     2,VSTRT
17516  34773         LDA     3,VADDR
17517  60077         NIO     77

17520    677 IN2:   JMP     IN1

17521   5000 LOFST:5000
17522   4000 LNWDS:4000
17523  73000 LSTRT:73000
17524  73000 LADDR:73000
17525  20774 .LOAD:LDA     0,LOFST
17526  24774         LDA     1,LNWDS
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---
   17527  30774        LDA    2,LSTRT
   17530  34774        LDA    3,LADDR
   17531  60077        NIO    77

   17532    574 .F:    JMP .F0
   17533    446 .H:    JMP    .H1
   17534    574 .P:    JMP    .P0      ;

          17600        .LOC   L.MANIP+600
   17600  63077        63077

             40 F=     40
            100 H=     100
            200 K=     200
            400 L=     400

             61        TPDI   =61
             61        TPCO   =61
             62        TPDO   =62
             60        TPSI   =60       ;STATUS DEVICE CODE
             63        TPCL   =63       ;DEVICE CODE FOR CLEAR ATTEN

   17601  40444 .H1:   STA    0,MODE   ;STORE OPERAND 1 AS READ MODE FOR QIC 11 OR QI
   17602 102400        SUB    0,0      ;AC0=0
   17603 105540        INCOL  0,1      ;AC1=3
   17604 111520        INCZL  0,2      ;AC2=2
   17605  62677        IORST  ;RESET TAPE SECTION INCLUDING ATNTAPE.
   17606  62377        DOBP   0,77     ;DISABLE TAPE DMA
   17607  62077        MSKO   0        ;TURN ON DMA CAPABILITY
   17610  20473        LDA    0,K4
   17611  61061        DOA    0,TPCO   ;ISSUE TAPE RESET (GIVES DEFAULT FORMAT)
   17612  60460        DIA    0,TPSI   ;READ STATUS
   17613 101300        MOVS   0,0
   17614 101112        SSP    0,0      ;CHECK FOR DIRECTION DISABLED
   17615    775        JMP    .-3
   17616  10763        ISZ    .H1      ;WAIT FOR MORE THAN 13 MICRO SECONDS ...
   17617    777        JMP    .-1      ;
   17620 102400        SUB    0,0      ;
   17621  61061        DOA    0,TPCO   ; ... BEFORE DISABLING RESET
   17622   4431 RSTA1:JSR    TCMD+2
   17623    300        300
   17624  60460        DIA    0,TPSI
   17625 101212        SKE    0,0      ;WAIT FOR TAPE NOT READY
   17626    776        JMP    .-2
   17627  60460 RSTA2:DIA    0,TPSI
   17630 101203        MOVR   0,0,SNC  ;WAIT FOR TAPE TO GO READY AGAIN
   17631    776        JMP    .-2
   17632  60461        DIA    0,TPDI   ;READ STATUS WORD
   17633  65061        DOA    1,TPCO   ;ACTIVATE REQUEST LINE
   17634  60460        DIA    0,TPSI
   17635 101212        SKE    0,0      ;WAIT FOR TAPE READY TO GO AWAY
   17636    776        JMP    .-2
   17637  10761        ISZ    RSTA1-2  ;WAIT FOR MORE THAN 20 MICRO SECONDS ...
   17640    777        JMP    .-1      ; ... BEFORE CLEARING REQUEST
   17641  71061        DOA    2,TPCO   ;DROP REQUEST LINE
   17642  10434        ISZ    CM6      ;READ SIX BYTES?
   17643    764        JMP    RSTA2    ;NO REPEAT
   17644   4405        JSR    TCMD
   17645    200 MODE:  200    ;CHANGED TO MODE COMMAND AT BEGINNING OF 'H' COMMAND
```

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---
17646   4403        JSR    TCMD
17647    200        200
17650    417        JMP    STAT

17651  10752 TCMD:  ISZ    RSTA1+1  ;
17652    777        JMP    .-1      ;
17653  21400        LDA    0,0,3    ;LOAD UP COMMMAND WORD
17654 101005        MOV    0,0,SNR  ;TEST FOR DEFAULT MODE
17655   1401        JMP    1,3      ;IF ZERO VALUE DO NOT ISSUE COMMAND
17656  61062        DOA    0,TPDO   ;ISSUE COMMAND
17657  65061        DOA    1,TPCO   ;ISSUE REQUEST
17660  60460        DIA    0,TPSI   ;WAIT FOR READY
17661 101213        SKO    0,0
17662    776        JMP    .-2
17663  14736        DSZ    RSTA1-1
17664    777        JMP    .-1
17665  71061        DOA    2,TPCO
17666   1401        JMP    1,3
17667  60460 STAT:  DIA    0,TPSI   ;HAS DIRECTION GONE TO READ?
17670 101300        MOVS   0,0
17671 101113        SSN    0,0
17672    775        JMP    .-3      ;NO

17673  20407        LDA    0,H377   ;PICK UP IDLE LOCATION
17674  40377        STA    0,377
17675   4404        JSR    .+4
17676 177772 CM6:   177772
17677 177777        177777
17700    777        777
17701  76377        DOBP   3,77     ;START TRANSFER
17702    377 H377:  377
17703      4 K4:    4      ;TAPE RESET COMMAND

17704 102400 .P1:   SUB    0,0
17705  41401        STA    0,1,3,   ;CLEAR SECTOR NUMBER, SECTOR COUNT
17706  41402        STA    0,2,3    ;CLEAR CYLINDER WORD
17707  41403        STA    0,3,3    ;SET MEMORY ADDRESS TO "0"
17710  41404        STA    0,4,3    ;ZERO TERMINATION STATUS
17711  62077        MSKO   0
17712  76277        DOBC   3,77
17713  25404 TERM:  LDA    1,4,3
17714 125113        SSN    1,1
17715    776        JMP    TERM
17716  30437        LDA    2,CMD
17717  41404        STA    0,4,3
17720  51400        STA    2,0,3
17721  76277        DOBC   3,77
17722  25404 TERM1: LDA    1,4,3
17723 125113        SSN    1,1
17724    776        JMP    TERM1
17725    377 P377:  JMP    377

17726  30425 .F0:   LDA    2,FDSEL  ;PICK UP FLOPPY SELECT WORD
17727    402        JMP    .P0+1
17730  30424 .P0:   LDA    2,DRSEL  ;PICK UP DRIVE SELECT WORD
17731  64457        DIA    1,57
17732 125300        MOVS   1,1
17733 125112        SSP    1,1
17734    775        JMP    .P0+1
```

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---
   17735 103120         ADDZL  0,0
   17736 103120         ADDZL  0,0
   17737 113000         ADD    0,2
   17740  71056         DOA    2,56
   17741  60457 .PRDY:DIA    0,57
   17742 103300         ADDS   0,0
   17743 101113         SSN    0,0
   17744    775         JMP    .PRDY
   17745   4737         JSR    .P1

;THE FOLLOWING 5 WORDS CONSTITUTE THE DISC IOCB

   17746  17400         17400  ;COMMAND (INITIALLY SET TO RESTORE AT 7.5MS STEPS)
   17747      4         .BLK   4

   17753     70 FDSEL:70      ;FLOPPY DRIVE SELECT WORD
   17754    240 DRSEL:240     ;HARD DISK DRIVE SELECT WORD
   17755  24000 CMD:  24000   ;READ COMMAND FOR CIOB

                      .EOT             ;MANIP
```

2.4 MARK 4 MANIP LISTING

This section contains the MANIP listing for the MARK 4.

MARK 4 MANIP LISTING (1 of 25)

```
NOV 23, 1987  15:21:27
; MANIP  --  RELOCATABLE RAM MANIPULATOR AND DEBUGGER FOR MARK 4 CPU
; WRITTEN BY RENNY BOSCH
; MODIFIED FOR MK4 BY JOE HARKINS
; 6 MAY 1985

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          77000       .LOC   77000

             12 P1S=  12
             13 P1D=  13
             10 TTY=  10

   77000  77000 PC:   77000          ;INITIAL PROGRAM COUNTER SAVED HERE

; ON ENTRY TO EACH OF THE "COMMAND LETTER" PROCEDURES,
;     A0 = FIRST OPERAND
;     A1 = SECOND OPERAND
;     A2 = FIRST OPERAND AS AN ADDRESS
;     A3 = B = CENTRAL REFERENCE POINT

   77001    434 MANP1:JMP    MANIP    ;HALT OR APL RESET ENTRY
   77002    433 MANP2:JMP    MANIP    ;RESERVED ... NOT CURRENTLY USED
   77003    425 MANP3:JMP    MNP2A    ;POWER UP ENTRY (MINI PANEL SWITCH = ON)
   77004    426 MANP4:JMP    MNP3A    ;POWER UP RESTART (MINI PANEL SWITCH = AUTO)
   77005      4       .BLK   4        ;RESERVED SPACE FOR ADDITIONAL ENTRY POINTS
   77011  20455 SPORT:LDA    0,RESET  ;PORT INITIALISATION
   77012  61046       DOA    0,TTY+36 ;BEGIN WITH PORT #16
   77013  24777       LDA    1,.-1
   77014  44403       STA    1,.+3
   77015  14402 SPRT1:DSZ    .+2      ;DECREMENT DOA INSTRUCTION ..
   77016  14401       DSZ    .+1      ;..BY 2 EACH TIME, THEN ISSUE COMMAND
   77017  61046       DOA    0,TTY+36 ;*******GETS MODIFIED BY PROGRAM*******
   77020  24777       LDA    1,.-1
   77021  30404       LDA    2,.+4
   77022 132414       SEQ    1,2      ;ALL PORTS INITIALISED ?
   77023    772       JMP    SPRT1    ;  NO, INITIALISE REMAINING PORTS
   77024  20443       LDA    0,BMODE  ;  YES, NOW SET UP PORTS 0 AND 1
   77025  61010       DOA    0,TTY
   77026  61012       DOA    0,TTY+2
   77027    523       JMP    RTN1

   77030   4761 MNP2A:JSR    SPORT
   77031    543       JMP    QE1
   77032   4757 MNP3A:JSR    SPORT
   77033 102400       SUB    0,0      ;SELECT DRIVE 0 FOR POWER UP IPL
   77034    541       JMP    PE1
```

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- PAGE 2 -
 77035  40441 MANIP:STA    0,A       ;START HERE
 77036  44441        STA    1,A+1     ;SAVE ACCUMULATORS AND CARRY
 77037  50441        STA    2,A+2
 77040  54441        STA    3,A+3
 77041 102560        SUBCL  0,0
 77042  40440        STA    0,A+4
 77043   4746        JSR    SPORT
 77044   5444        JSR    TYPE-B,3 ;OUTPUT TWO BELLS
 77045   3407        7*L+7
 77046   5415        JSR    TCRLF-B,3;TYPE CR


 77047  24731 .A:    LDA    1,PC      ;"A" = DUMP PC AND ACCUMLATORS
 77050   5422        JSR    TPOCT-B,3
 77051   5446        JSR    TPCLN-B,3
 77052  24424        LDA    1,A
 77053   5422        JSR    TPOCT-B,3
 77054  24423        LDA    1,A+1
 77055   5422        JSR    TPOCT-B,3
 77056  24422        LDA    1,A+2
 77057   5422        JSR    TPOCT-B,3
 77060  24421        LDA    1,A+3
 77061   5422        JSR    TPOCT-B,3
 77062  24420        LDA    1,A+4     ;AND CARRY
 77063   5422 TOCTI:JSR    TPOCT-B,3
 77064    401        JMP    INCM1

 77065    514 INCM1:JMP    INCMD


- PAGE 3 -

 77066      3 RESET:3      ;SOFTWARE RESET FOR UARTS, ALSO USED AS CONSTANT
 77067     11 BMODE:11     ;7 DATA  1 STOP  EVEN PARITY  INTS OFF
 77070      7 C7:   7
 77071    177 C177: 177

 77072      4 C4:   4
 77073     60 C60:  60
 77074     20 C20:  20
 77075      5 C5:   5

 77076      5 A:    .BLK   5         ;SAVE STATUS FOR CPU HERE

 77103  30772 .C:   LDA    2,C5      ;"C" = CHANGE ACCUMULATOR, C
 77104 142432        SGR    2,0       ;IS FIRST OPND <= 4 ?
 77105   1703 .CREF:JMP    ABORT-B,3

 77106 117000 .C1:   ADD    0,3
 77107  45602        STA    1,A-B,3   ;SAVE 2D OPND AS NEW CPU STATUS
 77110    471        JMP    INCMD

 77111  20771 .J:   LDA    0,A+4     ;"J" =JUMP; LOAD ACCUMULATORS
 77112 101200        MOVR   0,0       ;  AND CARRY
 77113  20763        LDA    0,A
 77114  24763        LDA    1,A+1
 77115  30763        LDA    2,A+2
 77116  34763        LDA    3,A+3
 77117   2555        JMP    @OP1      ;JUMP TO USER PROGRAM

 77120  21402 .K:   LDA    0,OP3-B,3;"K" = ENTER A CONSTANT IN CORE
 77121  41000        STA    0,0,2
 77122 151400        INC    2,2
 77123  11407        ISZ    COUNT-B,3
 77124    775        JMP    .-3
 77125   1705        JMP    INCMD-B,3
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- PAGE 4 -
   77126 106400 .M:   SUB    0,1       ;MOVE A BLOCK OF WORDS
   77127  35402        LDA    3,OP3-B,3;GET THE DESTINATION STARTING ADDRESS
   77130 102520        SUBZL  0,0
   77131 156033        SLS    2,3       ;IS SOURCE END < DESTINATION START ?
   77132    404        JMP    .M1       ;YES, DO A FORWARD MOVE
   77133 102000        ADC    0,0
   77134 133000        ADD    1,2
   77135 137000        ADD    1,3
   77136  25000 .M1:   LDA    1,0,2
   77137  45400        STA    1,0,3
   77140 113000        ADD    0,2
   77141 117000        ADD    0,3
   77142  10541        ISZ    COUNT
   77143    773        JMP    .M1
   77144    435        JMP    INCMD


; BRANCH.  BRANCHES TO THE DESTINATION INDICATED IN TABLE ENTRY IF THE
; RIGHT-MOST 7 (OR 5) BITS THEREOF AGREE WITH A0.  CALLING SEQUENCE:
;     JSR    BRNC7    (OR BRNC5 FOR 5-BIT, WITH A1 = 37)
;     DEST1-.-1*K+CHAR1(OR F INSTEAD OF K FOR 5-BIT)
;     DEST2-.-1*K+CHAR2
;       ...
;     END OF LIST IS INDICATED BY 7 (OR 5) LSB'S = 0

; A -1 IN THE TABLE IS USED TO DETERMINE MAX ALLOWABLE NO. OF OPERANDS

   77145  24724 BRNC7:LDA    1,C177
   77146 123400 BRNC5:AND    1,0
   77147  31400        LDA    2,0,3
   77150 175400        INC    3,3
   77151 147415        AND#   2,1,SNR   ;END OF LIST ?
   77152    521 RTN1: JMP    RTNA3     ;  YES
   77153 150015        COM#   2,2,SNR   ;IS LIST ENTRY = -1 ?
   77154  10525        ISZ    N.OP      ;  YES: MAX. NO. OPNDS. EXCEEDED ?
   77155 112421        SUBZ   0,2,SKP   ;  NO OR YES,NO
   77156    421        JMP    ABORT     ;  YES,YES
   77157 133414        AND#   1,2,SZR   ;MATCH ?
   77160    767        JMP    BRNC5+1   ;  NO
   77161 151113        SSN    2,2       ;IS DISPLACEMENT NEGATIVE ?
   77162 125620        INCZR  1,1       ;  NO - CHANGE A1 TO 100 (OR 20)
   77163 151200        MOVR   2,2
   77164 125224        MOVZR  1,1,SZR   ;SHIFTED 7 (OR 5) PLACES ?
   77165    776        JMP    .-2       ;  NO
   77166  20506        LDA    0,OP1
   77167  24506        LDA    1,OP2
   77170 157000        ADD    2,3
   77171 111000        MOV    0,2
   77172    501        JMP    RTNA3

   77173 177767 N.TS: B-TSEND;NO. TS CELLS TO BE CLEARED FOR NEW CMD

   77174    567 QE1:  JMP    QE2
   77175    567 PE1:  JMP    PE2
```

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- PAGE 5 -
 77176  60411        DIA    0,TTY+1
 77177   4541 ABORT:JSR    TYPE
 77200    134        "\
 77201   4510 INCMD:JSR    TCRLF     ;TYPE CR, LF
 77202   4536        JSR    TYPE      ;TYPE PROMPT
 77203  37055        ">*L+"-
 77204  54501        STA    3,.TS     ;INITIALIZE OPERAND STORAGE POINTER
 77205  14500        DSZ    .TS
 77206  24765        LDA    1,N.TS
 77207 102400        SUB    0,0
 77210  41400        STA    0,0,3     ;CLEAR TEMP STORE AREA
 77211 175400        INC    3,3
 77212 125404        INC    1,1,SZR
 77213    775        JMP    .-3
 77214  60410 INCHA:DIA    0,TTY     ;GET PORT 0 STATUS
 77215 125400        INC    1,1       ;BLINK THE CARRY
 77216 101213        SKO    0,0
 77217    775        JMP    INCHA     ;NO, STAY IN LOOP
 77220  60411        DIA    0,TTY+1   ;GET THE DATA WORD
 77221   4724        JSR    BRNC7     ;SEE IF IT'S AN ACTIVE CHARACTER
                    ;
 77222  31015        .CR-.-1*K+15      ;CARRIAGE RETURN
 77223  40736        .UP-.-1*K+"^      ;UP ARROW (EXAMINE PREVIOUS)
 77224 172433        ABORT-.-1*K+33
                    ;
 77225  20000 C20K: 20000             ;SERVES AS LIST TERMINATOR
                    ;
 77226  30467        LDA    2,C40
 77227 112032        SGE    0,2       ;IS IT A CNTRL CHAR ?
 77230    747        JMP    ABORT     ;YES, ABORT
 77231  61011        DOA    0,TTY+1   ;NOT ACTIVE, ECHO IT
 77232  30641        LDA    2,C60
 77233 142400        SUB    2,0
 77234  34634        LDA    3,C7
 77235 116432        SGR    0,3       ;IS IT AN OCTAL DIGIT ?
 77236    404        JMP    OCTAL     ;  YES
 77237 143023        ADDZ   2,0,SNC   ;RECONSTITUTE CHAR.; IS IT COMMA ?
 77240  40437 INCH2:STA    0,T       ;  NO, SAVE IT
 77241    412        JMP    SOCTF

 77242  10436 OCTAL:ISZ    OCTFL     ;FIRST OCTAL DIGIT OF A NUMBER ?
 77243  10442        ISZ    .TS       ;  YES, ADVANCE PARAMETER POINTER
 77244  26441        LDA    1,@.TS    ;PROCESS OCTAL CHARACTER
 77245 125120        MOVZL  1,1       ;SHIFT PREV. NO. LEFT 3 BITS
 77246 125120        MOVZL  1,1
 77247 125120        MOVZL  1,1
 77250 107000        ADD    0,1       ;ADD NEW DIGIT TO PREV. NO.
 77251  46434        STA    1,@.TS
 77252 102000        ADC    0,0
 77253  40425 SOCTF:STA    0,OCTFL   ;SET OCTAL FLAG
 77254    740        JMP    INCHA
```

- PAGE 6 -

```
77255   5415 .D:    JSR     TCRLF-B,3;"D" = DUMP MEMORY
77256  25400        LDA     1,OP1-B,3;GET THE STARTING ADDRESS
77257   5422        JSR     TPOCT-B,3;TYPE THE ADDRESS
77260   5446        JSR     TPCLN-B,3;TYPE A COLON
77261  27400 DLIN1:LDA     1,@OP1-B,3;GET THE DATA FROM MEMORY
77262   5423        JSR     TPOCL-B,3;TYPE THE DATA
77263  11400        ISZ     OP1-B,3  ;INC THE MEMORY POINTER
77264    401        JMP     .+1      ;ALLOW WRAP AROUND
77265  25400        LDA     1,OP1-B,3;GET THE NEW MEMORY ADDRESS
77266  20421        LDA     0,K7     ;GET 7
77267 107414        AND#    0,1,SZR  ;IS THE LEAST SIGNIFICANT DIGIT = 0?
77270    771        JMP     DLIN1    ;NO, CONTINUE DUMPING ON SAME LINE
77271    764        JMP     .D       ;YES, TYPE A NEW LINE

77272  34410 RTNTS:LDA     3,TS     ;RETURN VIA TS
77273   5400 RTNA3:JSR     0,3      ;RETURN VIA A3

       77274 B=     .       ;USED AS THE CENTRAL LOCATION REFERENCE ***

77274  77377 OP1:  VAR.    ;FIRST OPERAND TYPED IN (OCTAL)

77275  77377 OP2:  VAR.    ;2D OPND. (VALUE IN C, CONTROL IN D)

77276  77377 OP3:  VAR.    ;3D OPND. (ADDRESS IN D)


77277  77377 T:    VAR.    ;COMMAND LETTER

77300  77377 OCTFL:VAR.    ;OCTAL FLAG, CONTROLS OPERAND COUNTING

77301  77377 N.OP: VAR.    ;COUNTS NO. OF OPERANDS ENTERED

77302  77377 TS:   VAR.    ;GENERAL SUBROUTINE RETURN ADDRESS

77303  77377 COUNT:VAR.

77304  77377 FLAG: VAR.    ;FLAG USED IN :
       77305 TSEND=.       ;END OF VARIABLES INITIALIZED TO 0

77305  77377 .TS:  VAR.    ;POINTER TO ABOVE TEMP. STORE (INCMD)


       77377 VAR.= 77377  ;(PREVENTS UNNECESSARY PUNCHING)


77306      3 K3:   3
77307      7 K7:   7
77310     60 K60:  60

77311  54771 TCRLF:STA     3,TS     ;TYPE CARRIAGE RETURN, LINE FEED
77312   4426        JSR      TYPE
77313   5015        12*L+15
77314    756        JMP     RTNTS
```

- PAGE 7 -

```
77315     40 C40:  40

77316 152421 TPOCT:SUBZ   2,2,SKP  ;SUPPRESS LEADING ZEROES
77317  30776 TPOCL:LDA    2,C40    ;TYPE SPACES FOR LEADING ZEROES
77320  20775        LDA    0,C40    ;TYPE ONE INITIAL SPACE
77321  54761        STA    3,TS     ;TYPE THE OCTAL NO. IN A1, AFTER
77322   4422        JSR    TPCHA    ;  TYPING THE CHARACTER IN A0
77323 102620 TPA01:SUBZR  0,0      ;PREPARE TO MOVE MSB OF A1 INTO A0
77324 101041        MOVO   0,0,SKP  ;SET CARRY TO FORM "PUSHER" BIT
77325  20700 TPNXT:LDA    0,C20K   ;LEFT-SHIFT ONE DIGIT FROM A1 INTO A0
77326 125105        MOVL   1,1,SNR  ;INITIALLY INSERTS "PUSHER" BIT
77327    743        JMP    RTNTS    ;EXIT WHEN "PUSHER" BIT IS GONE
77330 101103        MOVL   0,0,SNC
77331    775        JMP    .-3
77332 101015        SNZ    0,0      ;NON-ZERO DIGIT  ...
77333 125135        MOVZL# 1,1,SNR  ;  ... OR LAST DIGIT ?
77334  30754        LDA    2,K60;  YES: ADDEND FOR ASCII DIGIT
77335 143040        ADDO   2,0
77336   4406        JSR    TPCHA
77337    766        JMP    TPNXT

77340  21400 TYPE: LDA    0,0,3    ;TYPE THE CHAR.(S) FOLL. THE JSR
77341 175401        INC    3,3,SKP
77342  20417 TPCLN:LDA    0,COLON  ;TYPE COLON
77343 101020 TP2CH:MOVZ   0,0      ;TYPE 2 CHARACTERS IN A0
77344  54456 TPCHA:STA    3,RTNTP
77345  74410 T1:   DIA    3,TTY    ;GET PORT 0 STATUS
77346 175202        MOVR   3,3,SZC  ;IS ANYTHING IN REC REG?
77347    627        JMP    ABORT-1  ; YES, ABORT
77350 175213        SKO    3,3      ;IS TRANSMIT REG EMPTY?
77351 175101        MOVL   3,3,SKP  ;RESTORE CARRY IF NO SKIP
77352 175101        MOVL   3,3,SKP  ;RESTORE CARRY IF SKIP
77353    772        JMP    .-6      ; NO, STAY IN LOOP
77354  34446        LDA    3,RTNTP
77355  61011 T2:   DOA    0,TTY+1
77356 101362 TPCH2:MOVCS  0,0,SZC  ;SECOND CHAR. TO BE TYPED ?
77357    765        JMP    TPCHA    ;  YES
77360    713        JMP    RTNA3

77361     72 COLON:":

77362    617 IN1:  JMP    INCMD
77363    537 QE2:  JMP    .QRY
77364 102520 PE2:  SUBZL  0,0
77365  40545        STA    0,VSTRT  ;USE AUTO ENTRY INTO SELF TEST
77366    546        JMP    .V+1
```

```
- PAGE 8 -
 77367 122000 .CR:  ADC    1,0       ;PROCESS CARRIAGE RETURN
 77370  41407       STA    0,COUNT-B,3
 77371  20714       LDA    0,.TS
 77372  24714       LDA    1,K3
 77373 122400       SUB    1,0
 77374 162422       SUBZ   3,0,SZC   ;> 3 OPERANDS ENTERED ?
 77375   1703       JMP    ABORT-B,3;  YES, ERROR
 77376  40703       STA    0,N.OP    ;NO. OF OPERANDS - 5
 77377  20700       LDA    0,T       ;BRANCH ON INITIAL LETTER
 77400   5651       JSR    BRNC7-B,3;COMMAND LETTER BRANCH TABLE
                    ;                ;MAX 3 OPERANDS
 77401 123513       .K-.-1*K+"K
 77402 124715       .M-.-1*K+"M
 77403  17300       .LOAD-.-1*K+"@
 77404 177777              -1        ;MAX 2 OPERANDS HEREAFTER
 77405  20720       .P-.-1*K+"P
 77406 117103       .C-.-1*K+"C
 77407   2672       .CLN-.-1*K+":
 77410 151104       .D-.-1*K+"D
 77411 177777              -1        ;MAX 1 OPERAND HEREAFTER
 77412 107101       .A-.-1*K+"A
 77413 117312       .J-.-1*K+"J
 77414  23526       .V-.-1*K+"V
 77415  12310       .H-.-1*K+"H
 77416   7706       .F-.-1*K+"F
 77417  20477       .QRY-.-1*K+"?
                    ;
 77420 177400 K377L:177400          ;SERVES AS LIST TERMINATOR
 77421   1703       JMP    ABORT-B,3

 77422  77377 RTNTP:VAR.   ;RETURN ADDRESS USED BY TPCHA


- PAGE 9 -

 77423  11405 .CLN: ISZ    N.OP-B,3 ;INPUT = COLON: TWO OPERANDS ?
 77424    417       JMP    .CLN1    ;  NO, DISPLAY CONTENT
 77425  45000       STA    1,0,2    ;  YES, STORE OP2 AT ADR1
 77426 102521 .CLN2:SUBZL  0,0,SKP  ;<< FROM .CLN1
 77427 102000 .UP:  ADC    0,0      ;"^" = EXAMINE PREVIOUS ADDRESS
 77430  25400       LDA    1,OP1-B,3
 77431 107000       ADD    0,1
 77432  45400       STA    1,OP1-B,3
 77433   5415 NXTL: JSR    TCRLF-B,3
 77434  25400       LDA    1,OP1-B,3
 77435   5422       JSR    TPOCT-B,3
 77436  45410       STA    1,FLAG-B,3;SET "EXAMINE" FLAG = 0
 77437  45401 .CLN3:STA    1,OP2-B,3;PREPARE FOR OCTAL INPUT --> OP2
 77440  55411       STA    3,.TS-B,3;(PRETEND ONE OPERAND HAS COME IN)
 77441   5446       JSR    TPCLN-B,3;TYPE A COLON
 77442   1744       JMP    INCH2-B,3;COUNT AS ONE OPERAND, SET T = ":"

 77443  21410 .CLN1:LDA    0,FLAG-B,3;2D OPERAND NOT TYPED IN
 77444 101014       SKZ    0,0      ;HAVE WE ALREADY EXAMINED IT ?
 77445    761       JMP    .CLN2    ;  YES, GO TO NEXT LINE
 77446  11410       ISZ    FLAG-B,3 ;  NO
 77447  25000       LDA    1,0,2
 77450   5423       JSR    TPOCL-B,3;TYPE THE VALUE AT OP1
 77451    766       JMP    .CLN3    ;TYPE A COLON & WAIT FOR INPUT

 77452    637 TYPCR:JMP    TCRLF
```

- PAGE 10 -

```
77453   7200 FOFST:7200
77454    200 FNWDS:200
77455     22 FSTRT:.F0-.P1
77456  40463 .F:    STA    0,TS0
77457  20774        LDA    0,FOFST
77460  24774        LDA    1,FNWDS
77461  30774        LDA    2,FSTRT
77462  50461        STA    2,STRT1
77463    461        JMP    XFER

77464   7000 HOFST:7000
77465    200 HNWDS:200
77466      0 HSTRT:0
77467  40452 .H:    STA    0,TS0
77470  20774        LDA    0,HOFST
77471  24774        LDA    1,HNWDS
77472  30774        LDA    2,HSTRT
77473  50450        STA    2,STRT1
77474    450        JMP    XFER

77475   3000 LOFST:3000
77476   4000 LNWDS:4000
77477  73000 LSTRT:73000
77500  73000 LADDR:73000
77501  20774 .LOAD:LDA    0,LOFST
77502  24774        LDA    1,LNWDS
77503  30774        LDA    2,LSTRT
77504  34774        LDA    3,LADDR
77505  60077        NIO    77

77506   7200 POFST:7200
77507    200 PNWDS:200
77510     24 PSTRT:.P0-.P1
77511  40430 .P:    STA    0,TS0
77512  20774        LDA    0,POFST
77513  24774        LDA    1,PNWDS
77514  30774        LDA    2,PSTRT
77515  50426        STA    2,STRT1
77516    426        JMP    XFER


77517  10000 QOFST:10000
77520    200 QNWDS:200
77521      0 QSTRT:0
77522  20775 .QRY: LDA    0,QOFST
77523  24775        LDA    1,QNWDS
77524  30775        LDA    2,QSTRT
77525  50416        STA    2,STRT1
77526    416        JMP    XFER

77527    633 IN2:   JMP    IN1
```

- PAGE 11 -

```
   77530   1000 VOFST:1000
   77531   2000 VNWDS:2000
   77532      0 VSTRT:0       ;LITERAL OFFSET INTO SELF TEST
   77533   4717 .V:    JSR    TYPCR
   77534  20774        LDA    0,VOFST
   77535  24774        LDA    1,VNWDS
   77536  30774        LDA    2,VSTRT
   77537  50404        STA    2,STRT1
   77540    404        JMP    XFER

   77541  63077 TS0:   HALT
   77542  63077 TS3:   HALT
   77543  63077 STRT1:HALT
   77544  54776 XFER: STA    3,TS3
   77545   4432        JSR    START-1  ;PICK UP MEMORY LOAD ADDRESS
   77546 171000        MOV    3,2
   77547   4406        JSR    XFER1
   77550  20771        LDA    0,TS0
   77551  34771        LDA    3,TS3
   77552  24771        LDA    1,STRT1
   77553 133000        ADD    1,2
   77554   1000        JMP    0,2
   77555  60077 XFER1:NIO    77

          77577        .LOC   PC+577
   77577   5400        JSR    0,3
   77600  63077 START:HALT   ;PROM LOAD AREA
L  77601    177        .BLK   177

             40 F=     40
            100 H=     100
            200 K=     200
            400 L=     400
```

```
                61      TPDI    =61
                61      TPCO    =61
                62      TPDO    =62
                60      TPSI    =60     ;STATUS DEVICE CODE
                63      TPCL    =63     ;DEVICE CODE FOR CLEAR ATTEN

L           106000      .LOC    PC+7000
             77601      .L.H:
                 1      D.H=.L.H-START


   77601  40444 .H1:   STA    0,MODE  ;STORE OPERAND 1 AS READ MODE FOR QIC 11 OR Q1
   77602 102400        SUB    0,0     ;AC0=0
   77603 105540        INCOL  0,1     ;AC1=3
   77604 111520        INCZL  0,2     ;AC2=2
   77605  62677        IORST  ;RESET TAPE SECTION INCLUDING ATNTAPE.
   77606  62377        DOBP   0,77    ;DISABLE TAPE DMA
   77607  62077        MSKO   0       ;TURN ON DMA CAPABILITY
   77610  20473        LDA    0,K4
   77611  61061        DOA    0,TPCO  ;ISSUE TAPE RESET (GIVES DEFAULT FORMAT)
   77612  60460        DIA    0,TPSI  ;READ STATUS
   77613 101300        MOVS   0,0
   77614 101112        SSP    0,0     ;CHECK FOR DIRECTION DISABLED
   77615    775        JMP    .-3
   77616  10763        ISZ    .H1     ;WAIT FOR MORE THAN 13 MICRO SECONDS ...
   77617    777        JMP    .-1     ;
   77620 102400        SUB    0,0     ;
   77621  61061        DOA    0,TPCO  ; ... BEFORE DISABLING RESET
   77622   4431 RSTA1:JSR    TCMD+2
   77623    300        300
   77624  60460        DIA    0,TPSI
   77625 101212        SKE    0,0     ;WAIT FOR TAPE NOT READY
   77626    776        JMP    .-2
   77627  60460 RSTA2:DIA    0,TPSI
   77630 101203        MOVR   0,0,SNC ;WAIT FOR TAPE TO GO READY AGAIN
   77631    776        JMP    .-2
   77632  60461        DIA    0,TPDI  ;READ STATUS WORD
   77633  65061        DOA    1,TPCO  ;ACTIVATE REQUEST LINE
   77634  60460        DIA    0,TPSI
   77635 101212        SKE    0,0     ;WAIT FOR TAPE READY TO GO AWAY
   77636    776        JMP    .-2
   77637  10761        ISZ    RSTA1-2 ;WAIT FOR MORE THAN 20 MICRO SECONDS ...
   77640    777        JMP    .-1     ; ... BEFORE CLEARING REQUEST
   77641  71061        DOA    2,TPCO  ;DROP REQUEST LINE
   77642  10434        ISZ    CM6     ;READ SIX BYTES?
   77643    764        JMP    RSTA2   ;NO REPEAT
   77644   4405        JSR    TCMD
   77645    200 MODE:  200    ;CHANGED TO MODE COMMAND AT BEGINNING OF 'H' COMMAND
   77646   4403        JSR    TCMD
   77647    200        200
   77650    417        JMP    STAT
```

```
77651  10752  TCMD:ISZ    RSTA1+1
77652    777        JMP    .-1
77653  21400        LDA    0,0,3     ;LOAD UP COMMMAND WORD
77654 101005        MOV    0,0,SNR   ;TEST FOR DEFAULT MODE
77655   1401        JMP    1,3       ;IF ZERO VALUE DO NOT ISSUE COMMAND
77656  61062        DOA    0,TPDO    ;ISSUE COMMAND
77657  65061        DOA    1,TPCO    ;ISSUE REQUEST
77660  60460        DIA    0,TPSI    ;WAIT FOR READY
77661 101213        SKO    0,0
77662    776        JMP    .-2
77663  14736        DSZ    RSTA1-1
77664    777        JMP    .-1
77665  71061        DOA    2,TPCO
77666   1401        JMP    1,3
77667  60460 STAT: DIA    0,TPSI    ;HAS DIRECTION GONE TO READ?
77670 101300        MOVS   0,0
77671 101113        SSN    0,0
77672    775        JMP    .-3       ;NO

77673  20407        LDA    0,H377    ;PICK UP IDLE LOCATION
77674  40377        STA    0,377
77675   4404        JSR    .+4
77676 177772 CM6:  177772
77677 177777       177777
77700    777       777
77701  76377        DOBP   3,77      ;START TRANSFER
77702    377 H377: 377
77703      4 K4:   4       ;TAPE RESET COMMAND
```

```
- PAGE 14 -
L        106200          .LOC   PC+7200
          77704          .L.P:
            104          D.P=.L.P-START


   77704 102400 .P1:   SUB    0,0
   77705  41401        STA    0,1,3,    ;CLEAR SECTOR NUMBER, SECTOR COUNT
   77706  41402        STA    0,2,3     ;CLEAR CYLINDER WORD
   77707  41403        STA    0,3,3     ;SET MEMORY ADDRESS TO "0"
   77710  41404        STA    0,4,3     ;ZERO TERMINATION STATUS
   77711  62077        MSKO   0
   77712  76277        DOBC   3,77
   77713  25404 TERM: LDA    1,4,3
   77714 125113        SSN    1,1
   77715    776        JMP    TERM
   77716  30437        LDA    2,CMD
   77717  41404        STA    0,4,3
   77720  51400        STA    2,0,3
   77721  76277        DOBC   3,77
   77722  25404 TERM1:LDA    1,4,3
   77723 125113        SSN    1,1
   77724    776        JMP    TERM1
   77725    377 P377: JMP    377


   77726  30425 .F0:  LDA    2,FDSEL   ;PICK UP FLOPPY SELECT WORD
   77727    402        JMP    .P0+1
   77730  30424 .P0:  LDA    2,DRSEL   ;PICK UP DRIVE SELECT WORD
   77731  64457        DIA    1,57
   77732 125300        MOVS   1,1
   77733 125112        SSP    1,1
   77734    775        JMP    .P0+1
   77735 103120        ADDZL  0,0
   77736 103120        ADDZL  0,0
   77737 113000        ADD    0,2
   77740  71056        DOA    2,56
   77741  60457 .PRDY:DIA    0,57
   77742 103300        ADDS   0,0
   77743 101113        SSN    0,0
   77744    775        JMP    .PRDY
   77745   4737        JSR    .P1

;THE FOLLOWING 5 WORDS CONSTITUTE THE DISC IOCB

   77746  17400        17400  ;COMMAND (INITIALLY SET TO RESTORE AT 7.5MS STEPS)
   77747      4        .BLK   4

   77753     70 FDSEL:70     ;FLOPPY DRIVE SELECT WORD
   77754    240 DRSEL:240    ;HARD DISK DRIVE SELECT WORD
   77755  24000 CMD:  24000  ;READ COMMAND FOR CIOB
```

```
- PAGE 15 -

L        107000 .LOC  PC+10000
          77756 .L.Q1:
            156 D.Q1=.L.Q1-START
              1 .TXTM 1

   77756    411        JMP     Q1BEG
   77757  10200 Q2OFS:10200
   77760    200 Q2NWD:200
   77761      0 Q2STR:0
   77762  20775 Q2XFR:LDA     0,Q2OFS
   77763  24775        LDA     1,Q2NWD
   77764  30775        LDA     2,Q2STR
   77765  50734        STA     2,STRT1+D.Q1
   77766    734        JMP     XFER+D.Q1;ELEVATOR TO XFER

   77767   4546 Q1BEG:JSR     MSG1      ;CLEAR SCREEN !
   77770   5012 .TXT   "<12><12>
   77771   5012
   77772   5012
   77773   5012
   77774   5012
   77775   5012
   77776   5012
   77777   5012
   100000   5012
   100001   5012
   100002   5012
   100003   5012
   100004   6400

   100005   4520       JSR     SPCS1
   100006   4517       JSR     SPCS1
   100007   4526       JSR     MSG1      ;WELCOME TO POINT 4 DATA'S MARK 4!
   100010  53505.TXT   "WE
   100011  46103LC
   100012  47515OM
   100013  42440E
   100014  52117TO
   100015  20120 P
   100016  47511OI
   100017  47124NT
   100020  20064 4
   100021  20104 D
   100022  40524AT
   100023  40447A'
   100024  51440S
   100025  46501MA
   100026  51113RK
   100027  20064 4
   100030  20407!
   100031   3415<07>
   100032   5012<12>
   100033   5000<12>"
```

- PAGE 16 -

```
100034   4471       JSR    SPCS1
100035   4500       JSR    MSG1      ;PLEASE ENTER COMMAND LETTER ETC.
100036  50114.TXT   "PL
100037  42501EA
100040  51505SE
100041  20105 E
100042  47124NT
100043  42522ER
100044  20103 C
100045  47515OM
100046  46501MA
100047  47104ND
100050  20114 L
100051  42524ET
100052  52105TE
100053  51040R
100054  24120(P
100055  46125LU
100056  51440S
100057  47520OP
100060  42522ER
100061  40516AN
100062  42050D(
100063  51451S)
100064  20127 W
100065  44105HE
100066  51105RE
100067  20101 A
100070  50120PP
100071  51117RO
100072  50122PR
100073  44501IA
100074  52105TE
100075  24415)
100076   5000<12>"
```

```
- PAGE 17 -
  100077   4426       JSR    SPCS1
  100100   4425       JSR    SPCS1
  100101   4434       JSR    MSG1      ;FOLLOWED BY A CARRIAGE RETURN
  100102  43117.TXT   "FO
  100103  46114LL
  100104  47527OW
  100105  42504ED
  100106  20102 B
  100107  54440Y
  100110  40440A
  100111  41501CA
  100112  51122RR
  100113  44501IA
  100114  43505GE
  100115  20122 R
  100116  42524ET
  100117  52522UR
  100120  47015N
  100121   5012<12>
  100122   5000<12>"


  100123    637       JMP    Q2XFR     ;FETCH NEXT MESSAGE BLOCK

  100124  77377RTNA1:77377
  100125  54777SPCS1:STA    3,RTNA1   ;SAVE RETURN ADDRESS
  100126   4407       JSR    MSG1
  100127  20040.TXT  "<40><40>
  100130  20040
  100131  20040
  100132  20040
  100133      0

  100134   2770       JMP    @RTNA1
  100135  25400MSG1: LDA    1,0,3     ;TYPE-OUT SUBROUTINE
  100136 175420       INCZ   3,3
  100137  20416MSG1A:LDA    0,Q1MSK   ;OUTPUT LEFT BYTE FIRST
  100140 123705       ANDS   1,0,SNR   ;ZERO BYTE (TERMINATOR) ?
  100141   1400       JMP    0,3       ;  YES, RETURN TO CALLER
  100142  61011       DOA    0,TTY+1   ;OUTPUT BYTE TO TTY
  100143  60410       DIA    0,TTY     ;GET PORT 0 STATUS
  100144 101202       MOVR   0,0,SZC   ;ANYTHING IN RECEIVE REGISTER?
  100145  63077       HALT   ;  YES, ABORT
  100146 101213       SKO    0,0       ;IS TRANSMIT REGISTER EMPTY?
  100147 101101       MOVL   0,0,SKP   ;  NO, RESTORE CARRY
  100150 101101       MOVL   0,0,SKP   ;  YES, RESTORE CARRY
  100151    772       JMP    .-6       ;STAY IN LOOP
  100152 125362       MOVCS  1,1,SZC   ;HAVE WE OUTPUT BOTH BYTES YET ?
  100153    764       JMP    MSG1A     ;  NO, DO THE RIGHT BYTE NOW
  100154    761       JMP    MSG1      ;  YES, GET NEXT 2 BYTES

  100155 177400Q1MSK:177400
```

- PAGE 18 -

```
L        107200 .LOC  PC+10200
         100156 .L.Q2:
            356 D.Q2=.L.Q2-START
              1 .TXTM 1

   100156    411      JMP     Q2BEG
   100157  10400Q3OFS:10400
   100160    200Q3NWD:200
   100161      0Q3STR:0
   100162  20775Q3XFR:LDA     0,Q3OFS
   100163  24775       LDA     1,Q3NWD
   100164  30775       LDA     2,Q3STR
   100165  50734       STA     2,STRT1+D.Q2
   100166    734       JMP     XFER+D.Q2;ELEVATOR TO XFER

   100167   4523Q2BEG:JSR     SPCS2
   100170   4522       JSR     SPCS2
   100171   4531       JSR     MSG2      ;A = DISPLAY CONTENTS OF ACCUMULATORS
   100172  40440.TXT   "A
   100173  36440=
   100174  42111DI
   100175  51520SP
   100176  46101LA
   100177  54440Y
   100200  41517CO
   100201  47124NT
   100202  42516EN
   100203  52123TS
   100204  20117 O
   100205  43040F
   100206  40503AC
   100207  41525CU
   100210  46525MU
   100211  46101LA
   100212  52117TO
   100213  51123RS
   100214  20015
   100215   5000<12>"
```

- PAGE 19 -

```
100216   4474       JSR     SPCS2
100217   4473       JSR     SPCS2
100220   4502       JSR     MSG2      ;C = CHANGE ACCUMULATOR CONTENTS
100221  41440.TXT   "C
100222  36440=
100223  41510CH
100224  40516AN
100225  43505GE
100226  20101 A
100227  41503CC
100230  52515UM
100231  52514UL
100232  40524AT
100233  47522OR
100234  20103 C
100235  47516ON
100236  52105TE
100237  47124NT
100240  51440S
100241   6412
100242      0"

100243   4447       JSR     SPCS2
100244   4446       JSR     SPCS2
100245   4455       JSR     MSG2      ;D = DISPLAY CONTENTS OF MEMORY
100246  42040.TXT   "D
100247  36440=
100250  42111DI
100251  51520SP
100252  46101LA
100253  54440Y
100254  41517CO
100255  47124NT
100256  42516EN
100257  52123TS
100260  20117 O
100261  43040F
100262  46505ME
100263  46517MO
100264  51131RY
100265   6412
100266      0"
```

- PAGE 20 -

```
100267   4423       JSR    SPCS2
100270   4422       JSR    SPCS2
100271   4431       JSR    MSG2      ;F = BOOT FROM FLOPPY DISK
100272  43040.TXT   "F
100273  36440=
100274  41117BO
100275  47524OT
100276  20106 F
100277  51117RO
100300  46440M
100301  43114FL
100302  47520OP
100303  50131PY
100304  20104 D
100305  44523IS
100306  45415K
100307   5000<12>"



100310    652       JMP    Q3XFR     ;FETCH NEXT MESSAGE BLOCK

100311  77377RTNA2:77377
100312  54777SPCS2:STA    3,RTNA2   ;SAVE RETURN ADDRESS
100313   4407       JSR    MSG2
100314  20040.TXT  "<40><40>
100315  20040
100316  20040
100317  20040
100320      0

100321   2770       JMP    @RTNA2
100322  25400MSG2: LDA    1,0,3     ;TYPE-OUT SUBROUTINE
100323 175420       INCZ   3,3
100324  20416MSG2A:LDA    0,Q2MSK   ;OUTPUT LEFT BYTE FIRST
100325 123705       ANDS   1,0,SNR   ;ZERO BYTE (TERMINATOR) ?
100326   1400       JMP    0,3       ;  YES, RETURN TO CALLER
100327  61011       DOA    0,TTY+1   ;OUTPUT BYTE TO TTY
100330  60410       DIA    0,TTY     ;GET PORT 0 STATUS
100331 101202       MOVR   0,0,SZC   ;ANYTHING IN RECEIVE REGISTER?
100332  63077       HALT   ;  YES, ABORT
100333 101213       SKO    0,0       ;IS TRANSMIT REGISTER EMPTY?
100334 101101       MOVL   0,0,SKP   ;  NO, RESTORE CARRY
100335 101101       MOVL   0,0,SKP   ;  YES, RESTORE CARRY
100336    772       JMP    .-6       ;STAY IN LOOP
100337 125362       MOVCS  1,1,SZC   ;HAVE WE OUTPUT BOTH BYTES YET ?
100340    764       JMP    MSG2A     ;  NO, DO THE RIGHT BYTE NOW
100341    761       JMP    MSG2      ;  YES, GET NEXT 2 BYTES

100342 177400Q2MSK:177400
```

- PAGE 21 -

```
L        107400 .LOC  PC+10400
         100343 .L.Q3:
            543 D.Q3=.L.Q3-START
              1 .TXTM 1

   100343    411      JMP     Q3BEG
   100344  10600Q4OFS:10600
   100345    200Q4NWD:200
   100346      0Q4STR:0
   100347  20775Q4XFR:LDA     0,Q4OFS
   100350  24775        LDA     1,Q4NWD
   100351  30775        LDA     2,Q4STR
   100352  50734        STA     2,STRT1+D.Q3
   100353    734        JMP     XFER+D.Q3;ELEVATOR TO XFER

   100354   4525Q3BEG:JSR     SPCS3
   100355   4524       JSR     SPCS3
   100356   4533       JSR     MSG3      ;H = LOAD FROM STREAMER TAPE
   100357  44040.TXT   "H
   100360  36440=
   100361  46117LO
   100362  40504AD
   100363  20106 F
   100364  51117RO
   100365  46440M
   100366  51524ST
   100367  51105RE
   100370  40515AM
   100371  42522ER
   100372  20124 T
   100373  40520AP
   100374  42415E
   100375   5000<12>"


   100376   4503       JSR     SPCS3
   100377   4502       JSR     SPCS3
   100400   4511       JSR     MSG3      ;K = STORE CONSTANT IN BLOCK OF MEMORY
   100401  45440.TXT   "K
   100402  36440=
   100403  51524ST
   100404  47522OR
   100405  42440E
   100406  41517CO
   100407  47123NS
   100410  52101TA
   100411  47124NT
   100412  20111 I
   100413  47040N
   100414  41114BL
   100415  47503OC
   100416  45440K
   100417  47506OF
   100420  20115 M
   100421  42515EM
   100422  47522OR
   100423  54415Y
   100424   5000<12>"
```

```
---


100425   4454       JSR     SPCS3
100426   4453       JSR     SPCS3
100427   4462       JSR     MSG3      ;M = MOVE A BLOCK IN MEMORY
100430  46440.TXT   "M
100431  36440=
100432  46517MO
100433  53105VE
100434  20101 A
100435  20102 B
100436  46117LO
100437  41513CK
100440  20111 I
100441  47040N
100442  46505ME
100443  46517MO
100444  51131RY
100445   6412
100446      0"


100447   4432       JSR     SPCS3
100450   4431       JSR     SPCS3
100451   4440       JSR     MSG3      ;P = PROGRAM LOAD FROM HARD DISC (BOOT)
100452  50040.TXT   "P
100453  36440=
100454  50122PR
100455  47507OG
100456  51101RA
100457  46440M
100460  46117LO
100461  40504AD
100462  20106 F
100463  51117RO
100464  46440M
100465  44101HA
100466  51104RD
100467  20104 D
100470  44523IS
100471  41440C
100472  24102(B
100473  47517OO
100474  52051T)
100475   6412
100476      0"
```

```
100477    650       JMP     Q4XFR     ;FETCH NEXT MESSAGE BLOCK

100500  77377RTN3A:77377
100501  54777SPCS3:STA     3,RTN3A   ;SAVE RETURN ADDRESS
100502   4407       JSR     MSG3
100503  20040.TXT "<40><40>
100504  20040
100505  20040
100506  20040
100507      0

100510   2770       JMP     @RTN3A
100511  25400MSG3:  LDA     1,0,3     ;TYPE-OUT SUBROUTINE
100512 175420       INCZ    3,3
100513  20416MSG3A:LDA     0,Q3MSK   ;OUTPUT LEFT BYTE FIRST
100514 123705       ANDS    1,0,SNR   ;ZERO BYTE (TERMINATOR) ?
100515   1400       JMP     0,3       ;  YES, RETURN TO CALLER
100516  61011       DOA     0,TTY+1   ;OUTPUT BYTE TO TTY
100517  60410       DIA     0,TTY     ;GET PORT 0 STATUS
100520 101202       MOVR    0,0,SZC   ;ANYTHING IN RECEIVE REGISTER?
100521  63077       HALT    ;  YES, ABORT
100522 101213       SKO     0,0       ;IS TRANSMIT REGISTER EMPTY?
100523 101101       MOVL    0,0,SKP   ;  NO, RESTORE CARRY
100524 101101       MOVL    0,0,SKP   ;  YES, RESTORE CARRY
100525    772       JMP     .-6       ;STAY IN LOOP
100526 125362       MOVCS   1,1,SZC   ;HAVE WE OUTPUT BOTH BYTES YET ?
100527    764       JMP     MSG3A     ;  NO, DO THE RIGHT BYTE NOW
100530    761       JMP     MSG3      ;  YES, GET NEXT 2 BYTES

100531 177400Q3MSK:177400
```

```
- PAGE 23 -

L        107600 .LOC  PC+10600
         100532 .L.Q4:
            732 D.Q4=.L.Q4-START
              1 .TXTM 1

   100532    411       JMP     Q4BEG
   100533  11000Q5OFS:11000
   100534    200Q5NWD:200
   100535      0Q5STR:0
   100536  20775Q5XFR:LDA     0,Q5OFS
   100537  24775       LDA     1,Q5NWD
   100540  30775       LDA     2,Q5STR
   100541  50734       STA     2,STRTl+D.Q4
   100542    734       JMP     XFER+D.Q4;ELEVATOR TO XFER

   100543   4510Q4BEG:JSR     SPCS4
   100544   4507       JSR     SPCS4
   100545   4516       JSR     MSG4      ;V = HARDWARE VERIFY TEST
   100546  53040.TXT   "V
   100547  36440=
   100550  44101HA
   100551  51104RD
   100552  53501WA
   100553  51105RE
   100554  20126 V
   100555  42522ER
   100556  44506IF
   100557  54440Y
   100560  52105TE
   100561  51524ST
   100562   6412
   100563      0"


   100564   4467       JSR     SPCS4
   100565   4466       JSR     SPCS4
   100566   4475       JSR     MSG4      ;: = OPEN SPECIFIC LOCATION TO EXAMINE OR STOI
   100567  35040.TXT   ":
   100570  36440=
   100571  47520OP
   100572  42516EN
   100573  20123 S
   100574  50105PE
   100575  41511CI
   100576  43111FI
   100577  41440C
   100600  46117LO
   100601  41501CA
   100602  52111TI
   100603  47516ON
   100604  20124 T
   100605  47440O
   100606  42530EX
   100607  40515AM
   100610  44516IN
   100611  42440E
   100612  47522OR
   100613  20123 S

---
   100614  52117TO
   100615  51105RE
   100616   6412
   100617      0"
```

- PAGE 24 -

```
100620   4433       JSR    SPCS4
100621   4432       JSR    SPCS4
100622   4441       JSR    MSG4      ;@ = LOAD FROM PROM (LOADS DEBUG AT 73000)
100623  40040.TXT   "@
100624  36440=
100625  46117LO
100626  40504AD
100627  20106 F
100630  51117RO
100631  46440M
100632  50122PR
100633  47515OM
100634  20050 (
100635  46117LO
100636  40504AD
100637  51440S
100640  42105DE
100641  41125BU
100642  43440G
100643  40524AT
100644  20067 7
100645  3146030
100646  3006000
100647  24415)
100650   5000<12>"
```

- PAGE 25 -

```
100651    665       JMP    Q5XFR     ;FETCH NEXT MESSAGE BLOCK

100652  77377RTN4A:77377
100653  54777SPCS4:STA    3,RTN4A   ;SAVE RETURN ADDRESS
100654   4407       JSR    MSG4
100655  20040.TXT  "<40><40>
100656  20040
100657  20040
100660  20040
100661      0

100662   2770       JMP    @RTN4A
100663  25400MSG4: LDA    1,0,3     ;TYPE-OUT SUBROUTINE
100664 175420       INCZ   3,3
100665  20416MSG4A:LDA    0,Q4MSK   ;OUTPUT LEFT BYTE FIRST
100666 123705       ANDS   1,0,SNR   ;ZERO BYTE (TERMINATOR) ?
100667   1400       JMP    0,3       ;  YES, RETURN TO CALLER
100670  61011       DOA    0,TTY+1   ;OUTPUT BYTE TO TTY
100671  60410       DIA    0,TTY     ;GET PORT 0 STATUS
100672 101202       MOVR   0,0,SZC   ;ANYTHING IN RECEIVE REGISTER?
100673  63077       HALT   ;  YES, ABORT
100674 101213       SKO    0,0       ;IS TRANSMIT REGISTER EMPTY?
100675 101101       MOVL   0,0,SKP   ;  NO, RESTORE CARRY
100676 101101       MOVL   0,0,SKP   ;  YES, RESTORE CARRY
100677    772       JMP    .-6       ;STAY IN LOOP
100700 125362       MOVCS  1,1,SZC   ;HAVE WE OUTPUT BOTH BYTES YET ?
100701    764       JMP    MSG4A     ;  NO, DO THE RIGHT BYTE NOW
100702    761       JMP    MSG4      ;  YES, GET NEXT 2 BYTES

100703 177400Q4MSK:177400
```

```
- PAGE 26 -

L        110000 .LOC  PC+11000
         100704 .L.Q5:
           1104 D.Q5=.L.Q5-START
              1 .TXTM 1

   100704    412      JMP     Q5BEG
   100705  11200Q6OFS:11200
   100706    200Q6NWD:200
   100707      0Q6STR:0
   100710    723Q6XFR:JMP    IN2+D.Q5 ;NO MORE MESSAGE BLOCKS, JUMP TO INCMD VIA IN2
   100711  20774      LDA    0,Q6OFS
   100712  24774      LDA    1,Q6NWD
   100713  30774      LDA    2,Q6STR
   100714  50733      STA    2,STRT1+D.Q5
   100715    733      JMP    XFER+D.Q5;ELEVATOR TO XFER

   100716   4424Q5BEG:JSR    SPCS5
   100717   4423      JSR    SPCS5
   100720   4432      JSR    MSG5     ;? = DISPLAY THIS HELP MENU
   100721  37440.TXT  "?
   100722  36440=
   100723  42111DI
   100724  51520SP
   100725  46101LA
   100726  54440Y
   100727  52110TH
   100730  44523IS
   100731  20110 H
   100732  42514EL
   100733  50040P
   100734  46505ME
   100735  47125NU
   100736   6412
   100737   5000

- PAGE 27 -

   100740    750      JMP    Q6XFR    ;FETCH NEXT MESSAGE BLOCK

   100741  77377RTN5A:77377
   100742  54777SPCS5:STA    3,RTN5A  ;SAVE RETURN ADDRESS
   100743   4407      JSR    MSG5
   100744  20040.TXT "<40><40>
   100745  20040
   100746  20040
   100747  20040
   100750      0

   100751   2770      JMP    @RTN5A
   100752  25400MSG5: LDA    1,0,3    ;TYPE-OUT SUBROUTINE
   100753 175420      INCZ   3,3
   100754  20416MSG5A:LDA    0,Q5MSK  ;OUTPUT LEFT BYTE FIRST
   100755 123705      ANDS   1,0,SNR  ;ZERO BYTE (TERMINATOR) ?
   100756   1400      JMP    0,3      ;  YES, RETURN TO CALLER
   100757  61011      DOA    0,TTY+1  ;OUTPUT BYTE TO TTY
   100760  60410      DIA    0,TTY    ;GET PORT 0 STATUS
   100761 101202      MOVR   0,0,SZC  ;ANYTHING IN RECEIVE REGISTER?
   100762  63077      HALT   ;  YES, ABORT
   100763 101213      SKO    0,0      ;IS TRANSMIT REGISTER EMPTY?
   100764 101101      MOVL   0,0,SKP  ;  NO, RESTORE CARRY
   100765 101101      MOVL   0,0,SKP  ;  YES, RESTORE CARRY
   100766    772      JMP    .-6      ;STAY IN LOOP
   100767 125362      MOVCS  1,1,SZC  ;HAVE WE OUTPUT BOTH BYTES YET ?
   100770    764      JMP    MSG5A    ;  NO, DO THE RIGHT BYTE NOW
   100771    761      JMP    MSG5     ;  YES, GET NEXT 2 BYTES

   100772 177400Q5MSK:177400
```

MARK 4 MANIP LISTING (25 of 25)

```
---
A       77076   ABORT   77177   B       77274   BMODE   77067   BRNC5   77146
BRNC7   77145   C177    77071   C20     77074   C20K    77225   C4      77072
C40     77315   C5      77075   C60     77073   C7      77070   CM6     77676
CMD     77755   COLON   77361   COUNT   77303   DLIN1   77261   DRSEL   77754
D.H         1   D.P       104   D.Q1      156   D.Q2      356   D.Q3      543
D.Q4      732   D.Q5     1104   F          40   FDSEL   77753   FLAG    77304
FNWDS   77454   FOFST   77453   FSTRT   77455   H         100   H377    77702
HNWDS   77465   HOFST   77464   HSTRT   77466   IN1     77362   IN2     77527
INCH2   77240   INCHA   77214   INCM1   77065   INCMD   77201   K         200
K3      77306   K377L   77420   K4      77703   K60     77310   K7      77307
L         400   LADDR   77500   LNWDS   77476   LOFST   77475   LSTRT   77477
MANIP   77035   MANP1   77001   MANP2   77002   MANP3   77003   MANP4   77004
MNP2A   77030   MNP3A   77032   MODE    77645   MSG1    100135  MSG1A   100137
MSG2    100322  MSG2A   100324  MSG3    100511  MSG3A   100513  MSG4    100663
MSG4A   100665  MSG5    100752  MSG5A   100754  NXTL    77433   N.OP    77301
N.TS    77173   OCTAL   77242   OCTFL   77300   OP1     77274   OP2     77275
OP3     77276   P1D        13   P1S        12   P377    77725   PC      77000
PE1     77175   PE2     77364   PNWDS   77507   POFST   77506   PSTRT   77510
Q1BEG   77767   Q1MSK   100155  Q2BEG   100167  Q2MSK   100342  Q2NWD   77760
Q2OFS   77757   Q2STR   77761   Q2XFR   77762   Q3BEG   100354  Q3MSK   100531
Q3NWD   100160  Q3OFS   100157  Q3STR   100161  Q3XFR   100162  Q4BEG   100543
Q4MSK   100703  Q4NWD   100345  Q4OFS   100344  Q4STR   100346  Q4XFR   100347
Q5BEG   100716  Q5MSK   100772  Q5NWD   100534  Q5OFS   100533  Q5STR   100535
Q5XFR   100536  Q6NWD   100706  Q6OFS   100705  Q6STR   100707  Q6XFR   100710
QE1     77174   QE2     77363   QNWDS   77520   QOFST   77517   QSTRT   77521
RESET   77066   RSTA1   77622   RSTA2   77627   RTN1    77152   RTN3A   100500
RTN4A   100652  RTN5A   100741  RTNA1   100124  RTNA2   100311  RTNA3   77273
RTNTP   77422   RTNTS   77272   SOCTF   77253   SPCS1   100125  SPCS2   100312
SPCS3   100501  SPCS4   100653  SPCS5   100742  SPORT   77011   SPRT1   77015
START   77600   STAT    77667   STRT1   77543   T       77277   T1      77345
T2      77355   TCMD    77651   TCRLF   77311   TERM    77713   TERM1   77722
TOCTI   77063   TP2CH   77343   TPA01   77323   TPCH2   77356   TPCHA   77344
TPCL       63   TPCLN   77342   TPCO        61   TPDI        61   TPDO        62
TPNXT   77325   TPOCL   77317   TPOCT   77316   TPSI        60   TS      77302
TS0     77541   TS3     77542   TSEND   77305   TTY         10   TYPCR   77452
TYPE    77340   VAR.    77377   VNWDS   77531   VOFST   77530   VSTRT   77532
XFER    77544   XFER1   77555   .A      77047   .C      77103   .C1     77106
.CLN    77423   .CLN1   77443   .CLN2   77426   .CLN3   77437   .CR     77367
.CREF   77105   .D      77255   .F      77456   .F0     77726   .H      77467
.H1     77601   .J      77111   .K      77120   .LOAD   77501   .L.H    77601
.L.P    77704   .L.Q1   77756   .L.Q2   100156  .L.Q3   100343  .L.Q4   100532
.L.Q5   100704  .M      77126   .M1     77136   .P      77511   .P0     77730
.P1     77704   .PRDY   77741   .QRY    77522   .TS     77305   .UP     77427
.V      77533
```

2.5 MARK 4E MANIP LISTING

This section contains the MANIP listing for the MARK 4E.

MARK 4E MANIP LISTING (1 of 12)

```
NOV  3, 1987  10:26:40
;*****************************************************************
; MANIP  --  RELOCATABLE RAM MANIPULATOR AND DEBUGGER
;                     FOR THE MARK 4E CPU
;
; WRITTEN BY RENNY BOSCH
; MODIFIED FOR MARK 4E BY BRUCE DOAN
; INITIAL RELEASE APRIL, 1987; LAST EDITED APRIL 15, 1987
;*****************************************************************

;                  All Rights Reserved
;      Copyright (C) 1975, Educational Data Systems
;        Copyright (C) 1986, Point 4 Data Corp.


          17000 L.ASM=        17000     ;ASSEMBLY LOCATION (ARBITRARY)
                                        ;17000 IS USED SO THAT SELFTEST STARTS AT
                                        ;20000

          17000 L.MANIP=      0+L.ASM   ;MANIP (MANIP IS PLACED AT LOC. 0 IN
                                        ;EPROM)
          20000 L.SELF=       1000+L.ASM;SELFTEST (@ LOCATION 1000 IN EPROM)
          22400 L.MENU=       3400+L.ASM;MENU TEXT (@ LOCATION 3400 IN EPROM)
          24000 L.DBUG=       5000+L.ASM;DBUG (@ LOCATION 5000 IN EPROM)
          27400 L.BZUD=       10400+L.ASM;BZUD FOR WD CONTROLLER (@ LOCATION
                                         ;10400 IN EPROM)

          77000 A.MANIP=      77000     ;CORE ADDRESS FOR MANIP
          20000 A.SELF=       20000     ;CORE ADDRESS FOR SELFTEST
          73000 A.DBUG=       73000     ;CORE ADDRESS FOR DBUG

          17000 .LOC  L.MANIP           ;ACTUAL LOCATION IS 77000

             12 P1S=  12                ;PORT 1 STATUS/COMMAND REGISTER
             13 P1D=  13                ;PORT 1 DATA REGISTER
             10 TTY=  10                ;PORT 0 STATUS/COMMAND REGISTER

   17000  77000 PC:   77000             ;INITIAL PROGRAM COUNTER SAVED HERE

; ON ENTRY TO EACH OF THE "COMMAND LETTER" PROCEDURES,
;      A0 = FIRST OPERAND
;      A1 = SECOND OPERAND
;      A2 = FIRST OPERAND AS AN ADDRESS
;      A3 = B = CENTRAL REFERENCE POINT

;MANIP ENTRY POINTS:

   17001    425 MANP1:JMP    MANIP     ;HALT OR RESET ENTRY POINT
   17002    424 MANP2:JMP    MANIP     ;RESERVED ... NOT CURRENTY USED
   17003    410 MANP3:JMP    MNP3A     ;POWER-UP ENTRY (FRONT PANEL SWITCH = ON)
   17004    412 MANP4:JMP    MNP4A     ;POWER-UP RESTART (FRONT PANEL SWITCH =
                                       ;AUTO)
   17005    414 MANP5:JMP    MNP5A     ;RE-ENTRY FROM SELFTEST (FRONT PANEL
                                       ;SWITCH = ON)
   17006    415 MANP6:JMP    MNP6A     ;RE-ENTRY FROM SELFTEST (FRONT PANEL
                                       ;SWITCH = AUTO)
   17007      1       .BLK   1         ;RESERVED SPACE FOR ADDITIONAL ENTRY PNTS

;SERIAL PORT COMMAND REGISTER INITIALIZATION
```

```
---
17010    555 SPORT:JMP    RTN1     ;USED TO BE PORT INITIALIZATION CODE


17011  20001 STEN1:SELF1           ;POWER-UP ENTRY POINT INTO SELFTEST (FRONT
                                    ;PANEL SWITCH = ON)
17012  20002 STEN2:SELF2           ;POWER-UP RESTART ENTRY POINT INTO
                                    ;SELFTEST (FRONT PANEL SWITCH = AUTO)

17013   4775 MNP3A:JSR    SPORT    ;
17014    445       JMP    .QRY     ; USED TO BE... LDA  0,STEN1
17015    574       JMP    JVE      ;LOAD SELFTEST, EXECUTE ONCE AND RETURN

17016   4772 MNP4A:JSR    SPORT    ;
17017  20773       LDA    0,STEN2  ;

17020    571       JMP    JVE      ;LOAD SELFTEST, EXECUTE ONCE, THEN BOOT

17021   4767 MNP5A:JSR    SPORT    ;
17022    437       JMP    .QRY     ;

17023   4765 MNP6A:JSR    SPORT    ;
17024 102400       SUB    0,0      ;FORCE DRIVE NUMBER=0 FOR POWER UP IPL
17025    563       JMP    JJP      ;JUMP TO .P0

17026  40463 MANIP:STA    0,A      ;WITH PREAMBLE COMPLETE, START MANIP HERE
17027  44463       STA    1,A+1    ;SAVE ACCUMULATORS AND CARRY
17030  50463       STA    2,A+2
17031  54463       STA    3,A+3
17032 102560       SUBCL  0,0
17033  40462       STA    0,A+4
17034   4754       JSR    SPORT
17035   5444       JSR    TYPE-B,3 ;OUTPUT TWO BELLS
17036   3407       7*L+7
17037   5415       JSR    TCRLF-B,3;TYPE CR

17040  24740 .A:   LDA    1,PC     ;"A" = DUMP PC AND ACCUMLATORS
17041   5422       JSR    TPOCT-B,3
17042   5446       JSR    TPCLN-B,3
17043  24446       LDA    1,A
17044   5422       JSR    TPOCT-B,3
17045  24445       LDA    1,A+1
17046   5422       JSR    TPOCT-B,3
17047  24444       LDA    1,A+2
17050   5422       JSR    TPOCT-B,3
17051  24443       LDA    1,A+3
17052   5422       JSR    TPOCT-B,3
17053  24442       LDA    1,A+4    ;AND CARRY
17054   5422 TOCTI:JSR    TPOCT-B,3
17055    401       JMP    INCM1

17056    537 INCM1:JMP    INCMD
17057      0 PRMA: 0
17060   3400 QMPTR:L.MENU-L.ASM

17061  20777 .QRY: LDA    0,QMPTR  ;"?" = PRINT MENU TEXT FROM APL PROM
17062  40775       STA    0,PRMA   ;A0=INITIAL POINTER INTO MENU TEXT
17063  20774 QLOOP:LDA    0,PRMA   ;
17064 126520       SUBZL  1,1      ;A1=1 (NUMBER OF WORDS TO READ FROM PROM)
17065   4402       JSR    .+2      ;JSR LOADS A3 WITH NEXT ADDRESS
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17066      0       0               ;2 BYTES OF TEXT READ FROM PROM ARE PLACED
                                   ;HERE
17067 171000       MOV     3,2     ;A3=A2=PREVIOUS ADDRESS
17070   4402       JSR     PMCT    ;JSR LOAD A3 WITH ADDRESS OF NIO 77 INSTR
17071  60077       NIO     77      ;WITH ACCUMULATORS SETUP, READ TEXT FROM
                                   ;PROM
17072   5400 PMCT: JSR     0,3     ;JUMP TO NIO 77 INSTRUCTION WHILE STORING
                                   ;NEXT ADDRESS IN A3
17073  20773       LDA     0,.-5   ;A0=WORD OF MENU TEXT JUST READ FROM PROM
17074 101015       SNZ     0,0     ;ARE BOTH BYTES OF MENU TEXT = 0?
17075    520       JMP     INCMD   ;YES, QUIT READING TEXT FROM PROM
17076   4511       JSR     JTP2C   ;NO, PRINT 2 CHARACTERS AND FETCH NEXT 2
17077  10760       ISZ     PRMA    ;INCREMENT POINTER INTO MENU TEXT
17100    763       JMP     QLOOP   ;

17101      3 RESET:3               ;SOFTWARE RESET FOR UARTS, ALSO USED AS A
                                   ;CONSTANT
17102     11 BMODE:11              ;7 DATA BITS, 1 STOP, EVEN PAR, INTS OFF
17103      7 C7:   7
17104    177 C177: 177
17105      4 C4:   4
17106     60 C60:  60
17107     20 C20:  20
17110      5 C5:   5

17111      5 A:    .BLK    5       ;SAVE STATUS FOR CPU HERE

17116  30772 .C:   LDA     2,C5    ;"C" = CHANGE ACCUMULATOR, C
17117 142432       SGR     2,0     ;IS FIRST OPND <= 4 ?
17120   1703 .CREF:JMP     ABORT-B,3

17121 117000 .C1:  ADD     0,3
17122  45601       STA     1,A-B,3 ;SAVE 2D OPND AS NEW CPU STATUS
17123    472       JMP     INCMD

17124  20771 .J:   LDA     0,A+4   ;"J" =JUMP; LOAD ACCUMULATORS
17125 101200       MOVR    0,0     ;  AND CARRY
17126  20763       LDA     0,A
17127  24763       LDA     1,A+1
17130  30763       LDA     2,A+2
17131  34763       LDA     3,A+3
17132   2556       JMP     @OP1    ;JUMP TO USER PROGRAM

17133  21402 .K:   LDA     0,OP3-B,3;"K" = ENTER A CONSTANT IN CORE
17134  41000       STA     0,0,2
17135 151400       INC     2,2
17136  11407       ISZ     COUNT-B,3
17137    775       JMP     .-3
17140   1705       JMP     INCMD-B,3
```

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- PAGE 2 -
   17141 106400 .M:    SUB     0,1        ;MOVE A BLOCK OF WORDS
   17142  35402        LDA     3,OP3-B,3;GET THE DESTINATION STARTING ADDRESS
   17143 102520        SUBZL   0,0
   17144 156033        SLS     2,3        ;IS SOURCE END < DESTINATION START ?
   17145    404        JMP     .M1        ;YES, DO A FORWARD MOVE
   17146 102000        ADC     0,0
   17147 133000        ADD     1,2
   17150 137000        ADD     1,3
   17151  25000 .M1:   LDA     1,0,2
   17152  45400        STA     1,0,3
   17153 113000        ADD     0,2
   17154 117000        ADD     0,3
   17155  10542        ISZ     COUNT
   17156    773        JMP     .M1

   17157    436        JMP     INCMD


; BRANCH.  BRANCHES TO THE DESTINATION INDICATED IN TABLE ENTRY IF THE
; RIGHT-MOST 7 (OR 5) BITS THEREOF AGREE WITH A0.  CALLING SEQUENCE:
;     JSR    BRNC7    (OR BRNC5 FOR 5-BIT, WITH A1 = 37)
;     DEST1-.-1*K+CHAR1(OR F INSTEAD OF K FOR 5-BIT)
;     DEST2-.-1*K+CHAR2
;       ...
;     END OF LIST IS INDICATED BY 7 (OR 5) LSB'S = 0

; A -1 IN THE TABLE IS USED TO DETERMINE MAX ALLOWABLE NO. OF OPERANDS

   17160  24724 BRNC7:LDA    1,C177
   17161 123400 BRNC5:AND    1,0
   17162  31400        LDA     2,0,3
   17163 175400        INC     3,3
   17164 147415        AND#    2,1,SNR    ;END OF LIST ?
   17165    522 RTN1:  JMP     RTNA3      ;  YES
   17166 150015        COM#    2,2,SNR    ;IS LIST ENTRY = -1 ?
   17167  10526        ISZ     N.OP       ;  YES: MAX. NO. OPNDS. EXCEEDED ?
   17170 112421        SUBZ    0,2,SKP    ;  NO OR YES,NO
   17171    422        JMP     ABORT      ;  YES,YES
   17172 133414        AND#    1,2,SZR    ;MATCH ?
   17173    767        JMP     BRNC5+1    ;  NO
   17174 151113        SSN     2,2        ;IS DISPLACEMENT NEGATIVE ?
   17175 125620        INCZR   1,1        ;  NO - CHANGE A1 TO 100 (OR 20)
   17176 151200        MOVR    2,2
   17177 125224        MOVZR   1,1,SZR    ;SHIFTED 7 (OR 5) PLACES ?
   17200    776        JMP     .-2        ;  NO
   17201  20507        LDA     0,OP1
   17202  24507        LDA     1,OP2
   17203 157000        ADD     2,3
   17204 111000        MOV     0,2
   17205    502        JMP     RTNA3

   17206 177767 N.TS: B-TSEND;NO. TS CELLS TO BE CLEARED FOR NEW CMD

   17207    550 JTP2C:JMP     TP2CH
   17210    567 JJP:   JMP     JP         ;ELEVATOR TO .P0
   17211    570 JVE:   JMP     VE         ;

   17212  60411        DIA     0,TTY+1
   17213   4541 ABORT:JSR     TYPE
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17214    134        "\
17215   4510 INCMD:JSR    TCRLF     ;TYPE CR, LF
17216   4536       JSR    TYPE      ;TYPE PROMPT
17217  37055       ">*L+"-
17220  54501       STA    3,.TS     ;INITIALIZE OPERAND STORAGE POINTER
17221  14500       DSZ    .TS
17222  24764       LDA    1,N.TS
17223 102400       SUB    0,0
17224  41400       STA    0,0,3     ;CLEAR TEMP STORE AREA
17225 175400       INC    3,3
17226 125404       INC    1,1,SZR
17227    775       JMP    .-3
17230  60410 INCHA:DIA    0,TTY     ;GET PORT 0 STATUS
17231 125400       INC    1,1       ;BLINK THE CARRY
17232 101213       SKO    0,0
17233    775       JMP    INCHA     ;NO, STAY IN LOOP
17234  60411       DIA    0,TTY+1   ;GET THE DATA WORD
17235   4723       JSR    BRNC7     ;SEE IF IT'S AN ACTIVE CHARACTER
                   ;
17236  31015       .CR-.-1*K+15     ;CARRIAGE RETURN
17237  40736       .UP-.-1*K+"^     ;UP ARROW (EXAMINE PREVIOUS)
17240 172433       ABORT-.-1*K+33
                   ;
17241  20000 C20K: 20000            ;SERVES AS LIST TERMINATOR
                   ;
17242  30467       LDA    2,C40
17243 112032       SGE    0,2       ;IS IT A CNTRL CHAR ?
17244    747       JMP    ABORT     ;YES, ABORT
17245  61011       DOA    0,TTY+1   ;NOT ACTIVE, ECHO IT
17246  30640       LDA    2,C60
17247 142400       SUB    2,0
17250  34633       LDA    3,C7
17251 116432       SGR    0,3       ;IS IT AN OCTAL DIGIT ?
17252    404       JMP    OCTAL     ;  YES
17253 143023       ADDZ   2,0,SNC   ;RECONSTITUTE CHAR.; IS IT COMMA ?
17254  40437 INCH2:STA    0,T       ;  NO, SAVE IT
17255    412       JMP    SOCTF

17256  10436 OCTAL:ISZ    OCTFL     ;FIRST OCTAL DIGIT OF A NUMBER ?
17257  10442       ISZ    .TS       ;  YES, ADVANCE PARAMETER POINTER
17260  26441       LDA    1,@.TS    ;PROCESS OCTAL CHARACTER
17261 125120       MOVZL  1,1       ;SHIFT PREV. NO. LEFT 3 BITS
17262 125120       MOVZL  1,1
17263 125120       MOVZL  1,1
17264 107000       ADD    0,1       ;ADD NEW DIGIT TO PREV. NO.
17265  46434       STA    1,@.TS
17266 102000       ADC    0,0
17267  40425 SOCTF:STA    0,OCTFL   ;SET OCTAL FLAG
17270    740       JMP    INCHA
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17271   5415 .D:    JSR     TCRLF-B,3;"D" = DUMP MEMORY
17272  25400        LDA     1,OP1-B,3;GET THE STARTING ADDRESS
17273   5422        JSR     TPOCT-B,3;TYPE THE ADDRESS
17274   5446        JSR     TPCLN-B,3;TYPE A COLON
17275  27400 DLIN1:LDA     1,@OP1-B,3;GET THE DATA FROM MEMORY
17276   5423        JSR     TPOCL-B,3;TYPE THE DATA
17277  11400        ISZ     OP1-B,3  ;INC THE MEMORY POINTER
17300    401        JMP     .+1      ;ALLOW WRAP AROUND
17301  25400        LDA     1,OP1-B,3;GET THE NEW MEMORY ADDRESS
17302  20421        LDA     0,K7     ;GET 7
17303 107414        AND#    0,1,SZR  ;IS THE LEAST SIGNIFICANT DIGIT = 0?
17304    771        JMP     DLIN1    ;NO, CONTINUE DUMPING ON SAME LINE
17305    764        JMP     .D       ;YES, TYPE A NEW LINE

17306  34410 RTNTS:LDA     3,TS     ;RETURN VIA TS
17307   5400 RTNA3:JSR     0,3      ;RETURN VIA A3

       17310 B=     .       ;USED AS THE CENTRAL LOCATION REFERENCE ***

17310  77377 OP1:  VAR.    ;FIRST OPERAND TYPED IN (OCTAL)

17311  77377 OP2:  VAR.    ;2D OPND. (VALUE IN C, CONTROL IN D)

17312  77377 OP3:  VAR.    ;3D OPND. (ADDRESS IN D)


17313  77377 T:    VAR.    ;COMMAND LETTER

17314  77377 OCTFL:VAR.    ;OCTAL FLAG, CONTROLS OPERAND COUNTING

17315  77377 N.OP: VAR.    ;COUNTS NO. OF OPERANDS ENTERED

17316  77377 TS:   VAR.    ;GENERAL SUBROUTINE RETURN ADDRESS

17317  77377 COUNT:VAR.

17320  77377 FLAG: VAR.    ;FLAG USED IN :
       17321 TSEND=.       ;END OF VARIABLES INITIALIZED TO 0

17321  77377 .TS:  VAR.    ;POINTER TO ABOVE TEMP. STORE (INCMD)


       77377 VAR.= 77377  ;(PREVENTS UNNECESSARY PUNCHING)


17322      3 K3:   3
17323      7 K7:   7
17324     60 K60:  60

17325  54771 TCRLF:STA     3,TS     ;TYPE CARRIAGE RETURN, LINE FEED
17326   4426        JSR      TYPE
17327   5015        12*L+15
17330    756        JMP     RTNTS
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17331     40 C40:  40

17332 152421 TPOCT:SUBZ   2,2,SKP  ;SUPPRESS LEADING ZEROES
17333  30776 TPOCL:LDA    2,C40    ;TYPE SPACES FOR LEADING ZEROES
17334  20775       LDA    0,C40    ;TYPE ONE INITIAL SPACE
17335  54761       STA    3,TS     ;TYPE THE OCTAL NO. IN A1, AFTER
17336   4422       JSR    TPCHA    ;  TYPING THE CHARACTER IN A0
17337 102620 TPA01:SUBZR  0,0      ;PREPARE TO MOVE MSB OF A1 INTO A0
17340 101041       MOVO   0,0,SKP  ;SET CARRY TO FORM "PUSHER" BIT
17341  20700 TPNXT:LDA    0,C20K   ;LEFT-SHIFT ONE DIGIT FROM A1 INTO A0
17342 125105       MOVL   1,1,SNR  ;INITIALLY INSERTS "PUSHER" BIT
17343    743       JMP    RTNTS    ;EXIT WHEN "PUSHER" BIT IS GONE
17344 101103       MOVL   0,0,SNC
17345    775       JMP    .-3
17346 101015       SNZ    0,0      ;NON-ZERO DIGIT  ...
17347 125135       MOVZL# 1,1,SNR  ;  ... OR LAST DIGIT ?
17350  30754       LDA    2,K60;  YES: ADDEND FOR ASCII DIGIT
17351 143040       ADDO   2,0
17352   4406       JSR    TPCHA
17353    766       JMP    TPNXT

17354  21400 TYPE: LDA    0,0,3    ;TYPE THE CHAR.(S) FOLL. THE JSR
17355 175401       INC    3,3,SKP
17356  20417 TPCLN:LDA    0,COLON  ;TYPE COLON
17357 101020 TP2CH:MOVZ   0,0      ;TYPE 2 CHARACTERS IN A0
17360  54456 TPCHA:STA    3,RTNTP
17361  74410 T1:   DIA    3,TTY    ;GET PORT 0 STATUS
17362 175202       MOVR   3,3,SZC  ;IS ANYTHING IN REC REG?
17363    627       JMP    ABORT-1  ; YES, ABORT
17364 175213       SKO    3,3      ;IS TRANSMIT REG EMPTY?
17365 175101       MOVL   3,3,SKP  ;RESTORE CARRY IF NO SKIP
17366 175101       MOVL   3,3,SKP  ;RESTORE CARRY IF SKIP
17367    772       JMP    .-6      ; NO, STAY IN LOOP
17370  34446       LDA    3,RTNTP
17371  61011 T2:   DOA    0,TTY+1
17372 101362 TPCH2:MOVCS  0,0,SZC  ;SECOND CHAR. TO BE TYPED ?
17373    765       JMP    TPCHA    ;  YES
17374    713       JMP    RTNA3

17375     72 COLON:":
17376  20001 STE1: 20001
17377    514 JP:   JMP    .PX      ;ELEVATOR TO .P0

17400    615 IN1:  JMP    INCMD

17401  40471 VE:   STA    0,VADDR  ;ENTRY POINT INTO SELFTEST
17402    472       JMP    .V+1     ;LOAD SELFTEST
```

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- PAGE 5 -
   17403 122000 .CR:  ADC    1,0       ;PROCESS CARRIAGE RETURN
   17404  41407        STA    0,COUNT-B,3
   17405  20714        LDA    0,.TS
   17406  24714        LDA    1,K3
   17407 122400        SUB    1,0
   17410 162422        SUBZ   3,0,SZC   ;> 3 OPERANDS ENTERED ?
   17411   1703        JMP    ABORT-B,3;  YES, ERROR
   17412  40703        STA    0,N.OP    ;NO. OF OPERANDS - 5
   17413  20700        LDA    0,T       ;BRANCH ON INITIAL LETTER
   17414   5650        JSR    BRNC7-B,3;COMMAND LETTER BRANCH TABLE
                       ;                ;MAX 3 OPERANDS
   17415 123313        .K-.-1*K+"K
   17416 124515        .M-.-1*K+"M
   17417  15500        .LOAD-.-1*K+"@
   17420 177777               -1        ;MAX 2 OPERANDS HEREAFTER
   17421  34120        .P-.-1*K+"P
   17422 116703        .C-.-1*K+"C
   17423   2672        .CLN-.-1*K+":
   17424 151104        .D-.-1*K+"D
   17425 177777               -1        ;MAX 1 OPERAND HEREAFTER
   17426 102301        .A-.-1*K+"A
   17427 117112        .J-.-1*K+"J
   17430  10526        .V-.-1*K+"V
   17431  14510        .H-.-1*K+"H
   17432  31506        .F-.-1*K+"F
   17433 105277        .QRY-.-1*K+"?
                       ;
   17434 177400 K377L:177400           ;SERVES AS LIST TERMINATOR
   17435   1703        JMP    ABORT-B,3

   17436  77377 RTNTP:VAR.    ;RETURN ADDRESS USED BY TPCHA
```

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17437  11405 .CLN: ISZ    N.OP-B,3 ;INPUT = COLON: TWO OPERANDS ?
17440    417       JMP    .CLN1     ;  NO, DISPLAY CONTENT
17441  45000       STA    1,0,2     ;  YES, STORE OP2 AT ADR1
17442 102521 .CLN2:SUBZL  0,0,SKP   ;<< FROM .CLN1
17443 102000 .UP:  ADC    0,0       ;"^" = EXAMINE PREVIOUS ADDRESS
17444  25400       LDA    1,OP1-B,3
17445 107000       ADD    0,1
17446  45400       STA    1,OP1-B,3
17447   5415 NXTL: JSR    TCRLF-B,3
17450  25400       LDA    1,OP1-B,3
17451   5422       JSR    TPOCT-B,3
17452  45410       STA    1,FLAG-B,3;SET "EXAMINE" FLAG = 0
17453  45401 .CLN3:STA    1,OP2-B,3;PREPARE FOR OCTAL INPUT --> OP2
17454  55411       STA    3,.TS-B,3;(PRETEND ONE OPERAND HAS COME IN)
17455   5446       JSR    TPCLN-B,3;TYPE A COLON
17456   1744       JMP    INCH2-B,3;COUNT AS ONE OPERAND, SET T = ":"

17457  21410 .CLN1:LDA    0,FLAG-B,3;2D OPERAND NOT TYPED IN
17460 101014       SKZ    0,0       ;HAVE WE ALREADY EXAMINED IT ?
17461    761       JMP    .CLN2     ;  YES, GO TO NEXT LINE
17462  11410       ISZ    FLAG-B,3  ;  NO
17463  25000       LDA    1,0,2
17464   5423       JSR    TPOCL-B,3;TYPE THE VALUE AT OP1
17465    766       JMP    .CLN3     ;TYPE A COLON & WAIT FOR INPUT

17466    637 TYPCR:JMP    TCRLF

17467   1000 VOFST:1000
17470  24000 VNWDS:24000
17471  20000 VSTRT:20000  ;LITERAL OFFSET INTO SELF TEST
17472  20000 VADDR:20000
17473   4773 .V:   JSR    TYPCR
17474  20773       LDA    0,VOFST
17475  24773       LDA    1,VNWDS
17476  30773       LDA    2,VSTRT
17477  34773       LDA    3,VADDR
17500  60077       NIO    77

17501    677 IN2:  JMP    IN1

17502   5000 LOFST:5000
17503   4000 LNWDS:4000
17504  73000 LSTRT:73000
17505  73000 LADDR:73000
17506  20774 .LOAD:LDA    0,LOFST
17507  24774       LDA    1,LNWDS
17510  30774       LDA    2,LSTRT
17511  34774       LDA    3,LADDR
17512  60077       NIO    77

17513    467 .PX:  JMP    .P;
17514    467 .H:   JMP    .H1

       17600       .LOC   L.MANIP+600
17600  63077       63077

          40 F=    40
         100 H=    100
---
         200 K=    200
         400 L=    400
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                61          TPDI    =61
                61          TPCO    =61
                62          TPDO    =62
                60          TPSI    =60         ;STATUS DEVICE CODE
                63          TPCL    =63         ;DEVICE CODE FOR CLEAR ATTEN

17601            527 .F:    JMP     .F0
17602            530 .P:    JMP     .P0         ;

17603          40444 .H1:   STA     0,MODE      ;STORE OPERAND 1 AS READ MODE FOR QIC 11 OR QI
17604         102400         SUB     0,0         ;AC0=0
17605         105540         INCOL   0,1         ;AC1=3
17606         111520         INCZL   0,2         ;AC2=2
17607          62677         IORST   ;RESET TAPE SECTION INCLUDING ATNTAPE.
17610          62377         DOBP    0,77        ;DISABLE TAPE DMA
17611          62077         MSKO    0           ;TURN ON DMA CAPABILITY
17612          20473         LDA     0,K4
17613          61061         DOA     0,TPCO      ;ISSUE TAPE RESET (GIVES DEFAULT FORMAT)
17614          60460         DIA     0,TPSI      ;READ STATUS
17615         101300         MOVS    0,0
17616         101112         SSP     0,0         ;CHECK FOR DIRECTION DISABLED
17617            775         JMP     .-3
17620          10763         ISZ     .H1         ;WAIT FOR MORE THAN 13 MICRO SECONDS ...
17621            777         JMP     .-1         ;
17622         102400         SUB     0,0         ;
17623          61061         DOA     0,TPCO      ; ... BEFORE DISABLING RESET
17624           4431 RSTA1:JSR     TCMD+2
17625            300         300
17626          60460         DIA     0,TPSI
17627         101212         SKE     0,0         ;WAIT FOR TAPE NOT READY
17630            776         JMP     .-2
17631          60460 RSTA2:DIA     0,TPSI
17632         101203         MOVR    0,0,SNC     ;WAIT FOR TAPE TO GO READY AGAIN
17633            776         JMP     .-2
17634          60461         DIA     0,TPDI      ;READ STATUS WORD
17635          65061         DOA     1,TPCO      ;ACTIVATE REQUEST LINE
17636          60460         DIA     0,TPSI
17637         101212         SKE     0,0         ;WAIT FOR TAPE READY TO GO AWAY
17640            776         JMP     .-2

17641          10761         ISZ     RSTA1-2     ;WAIT FOR MORE THAN 20 MICRO SECONDS ...
17642            777         JMP     .-1         ; ... BEFORE CLEARING REQUEST
17643          71061         DOA     2,TPCO      ;DROP REQUEST LINE
17644          10434         ISZ     CM6         ;READ SIX BYTES?
17645            764         JMP     RSTA2       ;NO REPEAT
17646           4405         JSR     TCMD
17647            200 MODE:   200     ;CHANGED TO MODE COMMAND AT BEGINNING OF 'H' COMMAND
17650           4403         JSR     TCMD
17651            200         200
17652            417         JMP     STAT
```

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17653  10752  TCMD:ISZ    RSTA1+1
17654    777       JMP    .-1
17655  21400       LDA    0,0,3     ;LOAD UP COMMMAND WORD
17656 101005       MOV    0,0,SNR   ;TEST FOR DEFAULT MODE
17657   1401       JMP    1,3       ;IF ZERO VALUE DO NOT ISSUE COMMAND
17660  61062       DOA    0,TPDO    ;ISSUE COMMAND
17661  65061       DOA    1,TPCO    ;ISSUE REQUEST
17662  60460       DIA    0,TPSI    ;WAIT FOR READY
17663 101213       SKO    0,0
17664    776       JMP    .-2
17665  14736       DSZ    RSTA1-1
17666    777       JMP    .-1
17667  71061       DOA    2,TPCO
17670   1401       JMP    1,3
17671  60460 STAT: DIA    0,TPSI    ;HAS DIRECTION GONE TO READ?
17672 101300       MOVS   0,0
17673 101113       SSN    0,0
17674    775       JMP    .-3       ;NO

17675  20407       LDA    0,H377    ;PICK UP IDLE LOCATION
17676  40377       STA    0,377
17677   4404       JSR    .+4
17700 177772 CM6:  177772
17701 177777       177777
17702    777       777
17703  76377       DOBP   3,77      ;START TRANSFER
17704    377 H377: 377
17705      4 K4:   4       ;TAPE RESET COMMAND

17706 102400 .P1:  SUB    0,0
17707  41401       STA    0,1,3,    ;CLEAR SECTOR NUMBER, SECTOR COUNT
17710  41402       STA    0,2,3     ;CLEAR CYLINDER WORD
17711  41403       STA    0,3,3     ;SET MEMORY ADDRESS TO "0"
17712  41404       STA    0,4,3     ;ZERO TERMINATION STATUS
17713  62077       MSKO   0
17714  76277       DOBC   3,77
17715  25404 TERM: LDA    1,4,3
17716 125113       SSN    1,1
17717    776       JMP    TERM
17720  30437       LDA    2,CMD
17721  41404       STA    0,4,3
17722  51400       STA    2,0,3
17723  76277       DOBC   3,77
17724  25404 TERM1:LDA    1,4,3
17725 125113       SSN    1,1
17726    776       JMP    TERM1
17727    377 P377: JMP    377

17730  30425 .F0:  LDA    2,FDSEL   ;PICK UP FLOPPY SELECT WORD
17731    402       JMP    .P0+1
17732  30424 .P0:  LDA    2,DRSEL   ;PICK UP DRIVE SELECT WORD
17733  64457       DIA    1,57
17734 125300       MOVS   1,1
17735 125112       SSP    1,1
17736    775       JMP    .P0+1
17737 103120       ADDZL  0,0
17740 103120       ADDZL  0,0
17741 113000       ADD    0,2
```

MARK 4E MANIP LISTING (12 of 12)

```
---
   17742  71056        DOA    2,56
   17743  60457 .PRDY:DIA    0,57
   17744 103300        ADDS   0,0
   17745 101113        SSN    0,0
   17746    775        JMP    .PRDY
   17747   4737        JSR    .P1

;THE FOLLOWING 5 WORDS CONSTITUTE THE DISC IOCB

   17750  17400        17400  ;COMMAND (INITIALLY SET TO RESTORE AT 7.5MS STEPS)
   17751      4        .BLK   4

   17755     70 FDSEL:70     ;FLOPPY DRIVE SELECT WORD
   17756    240 DRSEL:240    ;HARD DISK DRIVE SELECT WORD
   17757  24000 CMD:  24000  ;READ COMMAND FOR CIOB

                   .EOT            ;MANIP
```

COMMENT SHEET

MANUAL TITLE: MARK 2E/4/4E CPU Self-Test/MANIP Manual

PUBLICATION NO. HM-084-0069 REVISION A

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