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TESTING TELETYPES WITH A MICROCOMPUTER

J. S. BYRD

SAVANNAH RIVER LABORATORY
AIKEN, SOUTH CAROLINA 29801

PREPARED FOR THE U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION UNDER CONTRACT AT(07-2)-1

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Approved by

D. Baker, Manager
Laboratory Operations and Service

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ABSTRACT

An effective exerciser using a microcomputer was designed for ASR-33/35 *Teletypes*. The low-cost, portable instrument can be easily used by a maintenance technician to diagnose problems and to check out the *Teletype* after maintenance has been performed. The *Teletype* is operated under realistic, on-line conditions. System firmware includes programs for evaluation and diagnostic testing of all punching, reading, printing, and keying operations.

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INTRODUCTION

A *Teletype* (Registered trademark of Teletype Corp., Skokie, IL) communicates serial data for computers and other digital systems by means of a peripheral electromechanical keyboard. Routine preventive maintenance is required on these devices to enhance reliability and prolong the equipment lifetime. Due to long equipment downtimes involved with preventive and specific problem maintenance, a standby *Teletype* is usually substituted in the system, and maintenance is performed off-line.

Often problems associated with the *Teletype* are not apparent when they are tested off-line. Typical problems involve electrical timing synchronization between the mechanical operations and the electronic control signals from the system (for example, the computer). In order to effectively diagnose, repair, and test the *Teletype*, it should be operated in an on-line system configuration in which the keyboard is used to transmit data to the computer and back to the printer mechanism.

HARDWARE

A desk top microcomputer[1] designed and fabricated at Savannah River was used to build a portable exerciser to improve *Teletype* maintenance (Figure 1). (Available commercial microcomputers could also be adapted to this design.) The Savannah River system uses an Intel Model 8008[2] central processor module (microprocessor) and has a memory capacity of 1,024 8-bit bytes of PROM (programmable read-only memory) and 2,048 8-bit bytes of RAM (random access memory). Four 256- x 8-bit PROM modules are installed as firmware (permanently stored programs) that contain the *Teletype* test programs. The RAM is used for data storage. Also, short programs can be easily and quickly loaded with an integral keyboard (a unique feature of the Savannah River microcomputer) and operated in RAM for test routines not available in the firmware.

The *Teletype* plugs into a quick-disconnect connector on the rear of the microcomputer. The interface (Figure 2) between *Teletype* and microcomputer is a commercially available logic card, Model LTI-513.[3] The exerciser is electrically compatible with model ASR/KSR-33 and ASR/KSR-35 *Teletypes* that use 20-mA current loop transmission. Other configurations could be tested after minor circuit modifications.

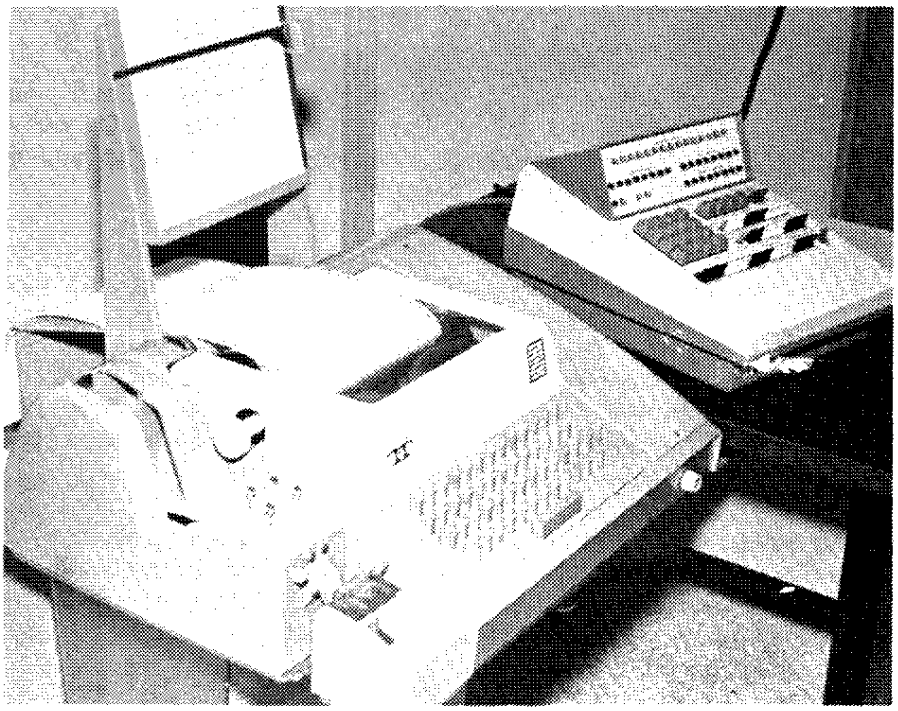

FIGURE 1. Teletype Exerciser

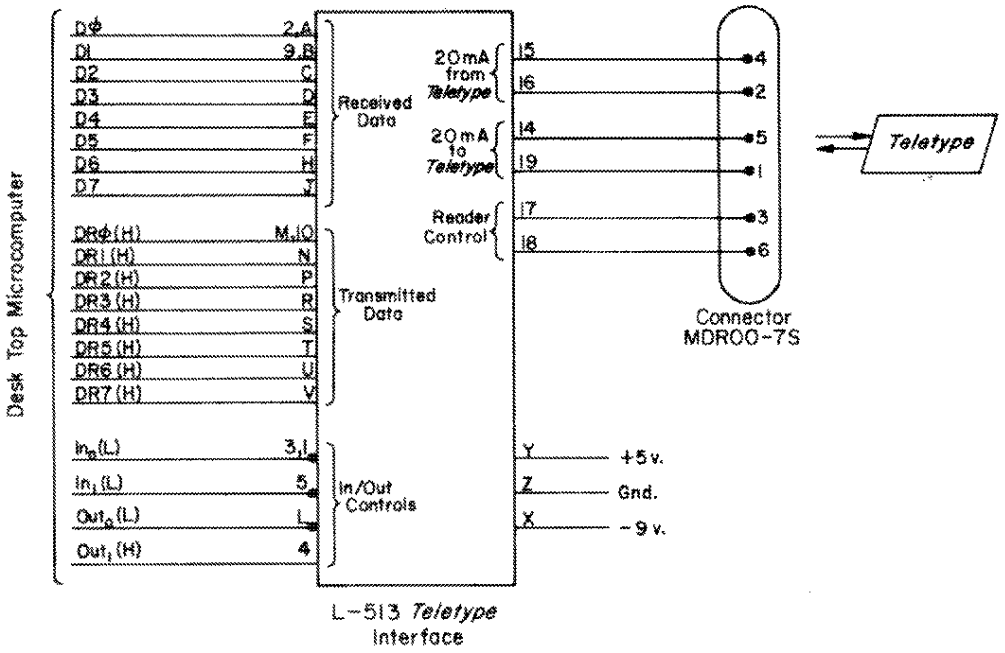

FIGURE 2. Interface Connection Diagram
(For description of Signals, see Reference 1.)
(Control Logic, Inc., Drawing 1002854)

FIRMWARE

The firmware consists of four pages of PROM. Each page is 256 8-bit bytes contained on an Intel Model 8702A PROM module. The PROM is erasable by exposure to ultraviolet light and may be reprogrammed to change the test routines.

The system program that is stored in the firmware (complete listing given in Appendix A) was written in fundamental machine code using L-Series Assembly Language.[4] A cross-assembler for a PDP-8E microcomputer (Digital Equipment Corp., Maynard, MA) was used; therefore, the programming effort was expedited with the advantages of an OS-8 disk-operated monitor system (Digital Equipment Corp., Maynard, MA),[5] a high-speed paper tape reader/punch, and a high-speed teleprinter.

The programs in the firmware are initiated from the microcomputer console with a single-byte restart instruction. The restart instruction starts the specified test routine by executing a jump instruction in the first seventy bytes of the first page in firmware.

TELETYPE TESTS

Eleven programs stored in the firmware test the following *Teletype* operations: carriage return, character space, line feed, character set keyboard entry, character set printing, and paper tape reading and punching. The programs are typical routines usually included in peripheral diagnostic software for computer systems. See Appendix B for test operating procedures.

Carriage Return

The carriage return (CR) operation is tested for line lengths of one to 70 characters. Seventy lines are typed (Figure 3) in which the first character is an M and remaining characters are X's. The message CR TEST is typed at the beginning of this test.

Line Feed

The line feed (LF) operation is tested by typing a back-diagonal character (\), then executing an LF, an (SP), and another \ until 70 lines have been typed (Figure 4). Proper alignment of the back-diagonals on the printout indicate correct LF (and SP) operations. The message LF TEST is typed before the test is executed.

```
CR TEST

M
MX
MXX
MXXX
MXXXX
MXXXXX
MXXXXXX
MXXXXXXX
MXXXXXXXX
MXXXXXXXXX
MXXXXXXXXXX
MXXXXXXXXXXX
MXXXXXXXXXXXX
MXXXXXXXXXXXXX
MXXXXXXXXXXXXXX
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MXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
MXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
MXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
MXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
```

FIGURE 3. Sample Printout for Carriage Return Test

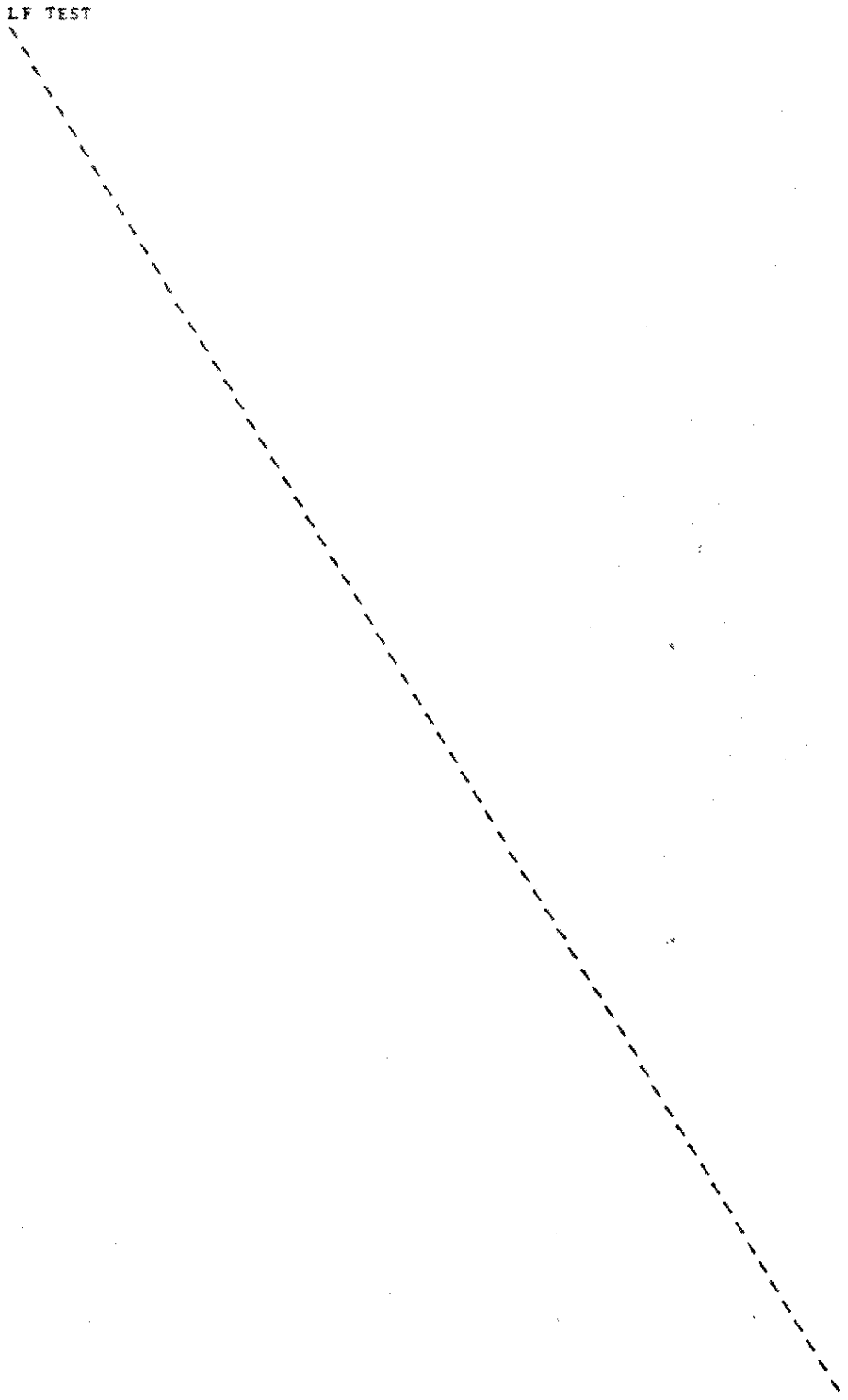

FIGURE 4. Sample Printout for Line Feed Test

Over-Print

After typing the message OVER-PRINT TEST, a 70-character line of X's is typed, a CR is executed, and the line of X's is typed again.

Space

After typing the message SP TEST, correct SP operation is tested by typing 34 X's on a line with spaces in between each character. A CR is executed, and 0's are typed in the spaces.

Swirl Pattern Character Print

All 63 printable characters are typed in a printout pattern that repeats the beginning line character at the end of the line (Figure 5). Each successive line begins with the second character on the previous line. A total of 65 lines are typed; the last character on the first line is the same as the first character on the last line. The message SWIRL PATTERN precedes the test pattern printout.

```
SWIRL PATTERN
 !"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !
"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#
$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#$%
&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#$%&'
()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#$%&'()
*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#$%&'()*+
,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#$%&'()*+,-
./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#$%&'()*+,-./
0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#$%&'()*+,-./01
23456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#$%&'()*+,-./0123
456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#$%&'()*+,-./012345
6789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^ !"#$%&'()*+,-./0123456
```

FIGURE 5. Sample Printout for Swirl Pattern Test

Worst Case Pattern Character

After the message WORST CASE is typed, the most difficult print pattern for the ASR/KSR-33 *Teletype* is executed (Figure 6). For this pattern, the print mechanism travels its maximum distance between characters. Twenty 64-character lines are typed.

```
WORST CASE
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/'←W/
```

FIGURE 6. Sample Printout for Worst Case Print Test

Character Echo

After a message ECHO TEST (HIT ANY KEY), the operator may strike any key on the keyboard. The exerciser will echo back the 7-bit ASCII (American Standard Code of Information Interchange) code for the key struck (Figure 7). A delete or rubout key will terminate this test.

```
ECHO TEST (HIT ANY KEY)
1= Ø61
2= Ø62
3= Ø63
4= Ø64
A= 1Ø1
B= 1Ø2
C= 1Ø3
D= 1Ø4
!= Ø41
"= Ø42
%= Ø45
&= Ø46
*= Ø52
```

FIGURE 7. Sample Printout for Character Echo Test

Line Echo

After a message LINE ECHO TEST (TYPE UP TO 70 CHARACTERS), the operator may type in a character string terminated with a BELL (Control G key). The line will be echoed by the exerciser (Figure 8). The test is terminated by striking the DELETE or RUBOUT key.

```
LINE ECHO TEST (TYPE UP TO 70 CHARACTERS)

TYPE IN ANY STRING OF CHARACTERS. TYPE A "BELL" TO ECHO LINE.
TYPE IN ANY STRING OF CHARACTERS. TYPE A "BELL" TO ECHO LINE.
ANOTHER LINE CAN NOW BE TYPED IN AND ECHOED.
ANOTHER LINE CAN NOW BE TYPED IN AND ECHOED.

TYPE "DELETE" TO GO TO ALTERNATE CHARACTER TEST.
```

FIGURE 8. Sample Printout for Line Echo Test

Alternate Character

The operator may strike successive keys. If an alternating character pattern is not repeated, the exerciser will type an error message, ERROR, ASCII = ____* (Figure 9). The test is preceded by the message ALTERNATE CHARACTER TEST.

```
ALTERNATE CHARACTER TEST
12121212121212122
ERROR, ASCII= 062
121212121223
ERROR, ASCII= 063
ABABABABABABABABB
ERROR, ASCII= 102
ABABABABABC
ERROR, ASCII= 103
HHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHHI
ERROR, ASCII= 111
KKKKKKKKKKKKKKKKKKKKKKKKKKK1
ERROR, ASCII= 061
```

FIGURE 9. Sample Printout for Alternate Character Test

---

* The ASCII Code for the incorrect character will be printed following the equals sign.

Punch and Reader

For Model ASR *Teletypes* with a paper tape reader/punch mechanism, two tests may be performed.

Punch/Read

A message PUNCH/READ TEST is printed at the beginning of this test. Blank tape is punched, followed by a numeric pattern type and more blank tape. The numeric pattern is then read and verified with the tape reader. If the numbers are different from the numbers programmed to be punched, an error printout indicates the actual and programmed data. The punch/read operation may be repeated automatically.

The test exercises all holes for the tape because the numeric pattern is a sequence of all 8-bit binary number combinations, followed by their one's complements. The sequence begins with one, increments through 377 (base 8), and decrements back to zero. Approximately 6 ft of paper tape is required for the sequence.

Reader

The reader test reads and verifies a prepunched binary sequence tape (the same pattern as used in previous punch/read test). The message READ TEST TAPE is printed at the start of this test.

ACKNOWLEDGEMENT

The author acknowledges the work of William E. McAlister, a Clemson University co-operative education student employee, who wrote the firmware programs during his employment at the Savannah River Laboratory in the summer of 1975.

APPENDIX A

Program Listing

The following listing shows the program stored in firmware PROM's.

```
                        /*****************************************************
                        /*                                                   *
                        /*  MICROCOMPUTER TELETYPE EXERCISER,     TTYTST   *
                        /*                                                   *
                        /*****************************************************
                        /
          000 000       SEL0=@0
          002 000       SEL1=@20
          006 000       SEL3=@60
          020 000       SEL8=@200
          022 000       SEL9=@220
          000           END=@0001
          000 010       PG10='10 0
                        /
          000 000       *0 '0
00 000 104 000 010 JMP  PG10          /BEGINNING OF RAM
          010 000       *10 '0
00 010 104 070 000 JMP  CRTST         /CHARACTER PRINT TESTS
          020 000       *20 '0
00 020 104 366 000 JMP SPPTST         /SWIRL PATTERN & WORSE CASE TESTS
          030 000       *30 '0
00 030 104 126 001 JMP ETST           /ECHO CHARACTERS & LINE TESTS
          040 000       *40 '0
00 040 104 062 001 JMP  WCTST         /WORSE CASE TEST
          050 000       *50 '0
00 050 104 053 002 JMP LEAD           /PUNCH & READ TAPE TESTS
          060 000       *60 '0
00 060 104 127 002 JMP TSTTP          /READ TEST TAPE
                        /
                        /*****CARRIAGE RETURN TESTS***********
                        /
          070 000       *70 '0
00 070 106 371 001 CRTST, CAL CRLF
00 073 106 371 001        CAL CRLF
00 076 066 336            LLI M1          /CR TEST MESSAGE
00 100 056 002            LHI 'M1
00 102 106 032 002        CAL PRINT
00 105 016 000            LBI 0           /SET B COUNTER TO ZERO
00 107 106 371 001 CRT,   CAL CRLF
00 112 301                LA B
00 113 074 106            CPI 106         /LAST LINE, B=106?
00 115 150 146 000        JTZ LFT         /YES: GO TO LF TEST
00 120 006 115            LAI "M          /NO: LOAD ASCII M
00 122 106 022 002        CAL SEND
00 125 010                INB             /INCREMENT B COUNTER
00 126 026 001            LCI 1
00 130 301          CHK,  LA B
00 131 272                CP C
00 132 150 107 000        JTZ CRT
00 135 006 130            LAI "X          /LOAD ASCII X
00 137 106 022 002        CAL SEND
00 142 020                INC
00 143 104 130 000        JMP CHK
                        /
                        /*****LINE FEED TESTS*****************
                        /
00 146 106 371 001 LFT,   CAL CRLF
00 151 106 371 001        CAL CRLF
00 154 066 350            LLI M2          /LF TEST MESSAGE
```

```
00 156 056 002              LHI 'M2
00 160 106 032 092          CAL PRINT
00 163 016 000              LBI 0           /SET B COUNTER TO ZERO
00 165 006 134      MARK,   LAI "\          /LOAD ASCII \
00 167 106 022 002          CAL SEND
00 172 006 012              LAI 12          /LOAD ASCII LF
00 174 106 022 002          CAL SEND
00 177 010                  INB             /INCREMENT B COUNTER
00 200 301                  LA B
00 201 074 106              CPI 106         /LAST SLASH, B=106?
00 203 110 165 000          JFZ MARK        /NO: PRINT \ AGAIN
                                            /YES: GO TO OVERPRINT TEST
                    /
                    /*****OVERPRINT TEST*********************
                    /
00 206 106 371 001 OPTST,   CAL CRLF
00 211 106 371 001          CAL CRLF
00 214 066 017              LLI M5          /OVERPRINT MESSAGE
00 216 056 003              LHI 'M5
00 220 106 032 002          CAL PRINT
00 223 016 130              LBI "X          /LOAD ASCII X
00 225 026 000              LCI 0
00 227 036 000              LDI 0
00 231 046 000              LEI 0
00 233 304          OPT,    LA E
00 234 106 022 002          CAL SEND
00 237 301                  LA B
00 240 106 022 002          CAL SEND
00 243 020                  INC
00 244 302                  LA C
00 245 074 106              CPI 106         /106=# OF CHAR IN 1 LINE?
00 247 110 233 000          JFZ OPT         /NO:NEXT CHARACTER
00 252 026 000              LCI 0
00 254 006 015              LAI 15          /LOAD ASCII CR
00 256 106 022 002          CAL SEND
00 261 030                  IND
00 262 303                  LA D
00 263 074 002              CPI 2           /1 OVERPRINT ONLY
00 265 110 233 000          JFZ OPT
00 270 006 012              LAI 12          /LOAD ASCII LF
00 272 106 022 002          CAL SEND
                    /
                    /*****SPACE TESTS*********************
                    /
00 275 106 371 001 SPTST,   CAL CRLF
00 300 106 371 001          CAL  CRLF
00 303 066 041              LLI  M6         /SP TEST MESSAGE
00 305 056 003              LHI  'M6
00 307 106 032 002          CAL  PRINT
00 312 046 274              LEI  274        /-104
00 314 006 130      PRNX,   LAI  "X         /LOAD ASCII X
00 316 106 022 002          CAL  SEND       /PRINT X
00 321 040                  INE
00 322 006 040              LAI  40         /LOAD ASCII SP
00 324 106 022 002          CAL  SEND       /SPACE
00 327 040                  INE
00 330 110 314 000          JFZ  PRNX       /104 CHARACTERS
00 333 006 015              LAI  15         /LOAD ASCII CR
00 335 106 022 002          CAL SEND        /CARRIAGE RETURN
00 340 304                  LA E
```

```
00 341 106 022 002          CAL SEND        /NULL CHARACTER
00 344 046 274              LEI  274        /-104
00 346 006 040      PRNO,   LAI  40
00 350 106 022 002          CAL SEND        /SPACE
00 353 040                  INE
00 354 006 117              LAI  "O         /LOAD ASCII O
00 356 106 022 002          CAL SEND        /PRINT O
00 361 040                  INE
00 362 110 346 000          JFZ  PRNO       /104 CHARACTERS
00 365 377                  HLT             /STOP

                    /
                    /*****SWIRL PATTERN CHARACTER TEST***************
                    /
00 366 106 371 001 SPPTST,  CAL CRLF
00 371 106 371 001          CAL CRLF
00 374 066 377              LLI M4          /SWIRL MESSAGE
00 376 056 002              LHI 'M4
01 000 106 032 002          CAL PRINT
01 003 016 040              LBI 40          /FIRST CHARACTER, A SPACE
01 005 026 000              LCI 0
01 007 036 000              LDI 0
01 011 301          SPT,    LA B
01 012 106 022 002          CAL SEND
01 015 020                  INC
01 016 010                  INB
01 017 301                  LA B
01 020 074 137              CPI "_          /LAST CHARACTER IS _?
01 022 150 030 001          JTZ CHB         /YES: CHANGE B SEQUENCE
01 025 104 011 001          JMP SPT         /NO: PRINT B
01 030 016 040      CHB,    LBI 40
01 032 301          CH2,    LA B
01 033 106 022 002          CAL SEND
01 036 010                  INB
01 037 020                  INC
01 040 302                  LA C
01 041 074 101              CPI 101         /101=# OF CHAR IN 1 LINE?
01 043 110 032 001          JFZ CH2         /NO: REPEAT PRINT SEQUENCE
01 046 106 371 001          CAL CRLF        /YES: NEXT LINE
01 051 026 000              LCI 0
01 053 030                  IND
01 054 303                  LA D
01 055 074 100              CPI 100         /100=# OF LINES?
01 057 110 011 001          JFZ SPT         /NO: NEXT LINE
                                            /YES: GO TO WORSE CASE TEST
                    /
                    /*****WORSE CASE TEST FOR ASR-33**************
                    /
01 062 106 371 001 WCTST,   CAL CRLF
01 065 106 371 001          CAL CRLF
01 070 066 235              LLI  M11        /WORSE CASE MESSAGE
01 072 056 003              LHI  'M11
01 074 106 032 002          CAL PRINT
01 077 026 354              LCI  354        /LINE COUNTER, -24
01 101 016 370      BLOOP,  LBI  370        /CHARACTER STRING COUNTER
01 103 066 252              LLI  M12        /WORSE CASE CHARACTER STRING
01 105 056 003              LHI  'M12
01 107 106 032 002          CAL  PRINT
01 112 010                  INB             /INCREMENT B
01 113 110 103 001          JFZ  BLOOP+2    /REG. B NOT ZERO, REPEAT
01 116 106 371 001          CAL CRLF
```

```
01 121 020                      INC             /INCREMENT C
01 122 110 101 001              JFZ  BLOOP      /REG. C NOT ZERO
01 125 377                      HLT             /STOP PROGRAM
                        /
                        /*****ECHO CHARACTER TEST******************
                        /
01 126 106 371 001 ETST,    CAL CRLF
01 131 106 371 001          CAL CRLF
01 134 066 056              LLI M7          /ECHO TEST MESSAGE
01 136 056 003              LHI ^M7
01 140 106 032 002          CAL PRINT
01 143 036 001      CHT,    LDI 1
01 145 106 004 002          CAL READ        /INPUT FROM KEYBOARD
01 150 340                  LE A
01 151 304          COMP,   LA E
01 152 273                  CP D
01 153 150 170 001          JTZ REPLY
01 156 030                  IND
01 157 303                  LA D
01 160 074 177              CPI 177         /TEST FOR DELETE
01 162 110 151 001          JFZ COMP        /REPEAT CHAR ECHO
01 165 104 206 001          JMP LETST       /DELETE WAS TYPED
01 170 006 075      REPLY,  LAI "=          /LOAD ASCII =
01 172 106 022 002          CAL SEND
01 175 106 300 002          CAL RPRT+1        /ARRANGE & SEND
01 200 106 371 001          CAL CRLF
01 203 104 143 001          JMP CHT
                        /
                        /*****LINE ECHO TEST******************
                        /
01 206 106 371 001 LETST, CAL CRLF
01 211 106 371 001          CAL CRLF
01 214 066 110              LLI M8          /LINE ECHO MESSAGE
01 216 056 003              LHI ^M8
01 220 106 032 002          CAL PRINT
01 223 066 000      LNTI1,  LLI  0          /STORE LINE AT ^10, 00
01 225 056 010              LHI  10
01 227 106 371 001          CAL CRLF
01 232 106 004 002 LNTI2, CAL READ        / INPUT FROM KEYBOARD
01 235 370                  LM M
01 236 074 007              CPI 07          /CHECK FOR BELL
01 240 150 257 001          JTZ LNTO
01 243 074 177              CPI 177         /CHECK FOR DELETE
01 245 150 302 001          JTZ ACTST       /GO TO ALT CHAR TEST
01 250 060                  INL
01 251 306                  LA L
01 252 074 107              CPI 107         /107=MAX # OF CHAR?
01 254 110 232 001          JFZ  LNTI2
01 257 106 371 001 LNTO,  CAL CRLF
01 262 336                  LD L
01 263 066 377              LLI 377
01 265 060          SEC,    INL
01 266 307                  LA M
01 267 106 022 002          CAL SEND        /PRINT OUT LINE TYPED IN
01 272 306                  LA L
01 273 273                  CP D
01 274 110 265 001          JFZ SEC
01 277 104 223 001          JMP LNTI1
                        /
                        /*****ALTERNATE CHARACTER TEST**********************
```

```
                        /
01 302 106 371 001 ACTST, CAL CRLF
01 305 106 371 001         CAL CRLF
01 310 066 164             LLI M9          /ALTERNATE CHARACTER MESSAGE
01 312 056 003             LHI 'M9
01 314 106 032 002         CAL PRINT
01 317 106 004 002 FST1,   CAL READ        / TYPE IN FIRST CHARACTER
01 322 330                 LD A
01 323 106 004 002 SEC1,   CAL READ        / TYPE IN SECOND CHARACTER
01 326 320                 LC A
01 327 106 004 002 AREST,  CAL READ       / ALL ODD CHAR SAME AS 1ST
01 332 273                 CP D
01 333 110 345 001         JFZ ERM1
01 336 106 004 002 BREST,  CAL READ       / ALL EVEN SAME AS 2ND CHAR
01 341 272                 CP C
01 342 150 327 001         JTZ AREST
01 345 340         ERM1,   LE A
01 346 106 371 001         CAL CRLF
01 351 066 217             LLI M10         /MESSAGE
01 353 056 003             LHI 'M10
01 355 106 032 002         CAL PRINT
01 360 106 300 002         CAL RPRT+1        /ARRANGE & SEND
01 363 106 371 001         CAL CRLF
01 366 104 317 001         JMP FST1        /GET NEXT CHARACTER PAIR
                        /
                        /----SUBROUTINE FOR CR/LF-----------
                        /
01 371 006 015     CRLF, LAI 15          / CARRIAGE RETURN
01 373 106 022 002 CAL SEND
01 376 006 012     LAI 12                / LINE FEED
02 000 106 022 002 CAL SEND
02 003 007         RET
                        /
                        /
                        /-----SUBROUTINE TO INPUT KEYBOARD------------
                        /
02 004 103         READ, INP SEL1
02 005 032         RAR
02 006 100 004 002 JFC READ
02 011 101         INP SEL0
02 012 310         LB A
02 013 106 022 002 CAL SEND
02 016 301         LA B
02 017 044 177     NDI 177
02 021 007         RET
                        /
                        /-----SUBROUTINE TO OUTPUT TO TTY--------
                        /
02 022 121         SEND, OUT SEL8
02 023 103         INP SEL1
02 024 032         RAR
02 025 032         RAR
02 026 100 023 002 JFC SEND+1
02 031 007         RET
                        /
                        /----SUBROUTINE TO PRINT CHARACTER STRING--------
                        /
02 032 307         PRINT, LA M
02 033 074 000     CPI 0
02 035 053         RTZ                     /RETURN ON ZERO CHARACTER
```

```
02 036 106 022 002 CAL SEND
02 041 106 047 002 CAL INHL
02 044 104 032 002 JMP PRINT
                   /
                   /----SUBROUTINE TO INCREMENT MEMORY ADDR----------
                   /
02 047 060         INHL,  INL
02 050 013         RFZ
02 051 050         INH
02 052 007         RET
                   /
                   /*****READER/PUNCH TEST**********
                   /
02 053 106 371 001 LEAD,  CAL CRLF        /PUNCH-READ TAPE
02 056 106 371 001        CAL CRLF
02 061 066 263            LLI M13         /MESSAGE
02 063 056 003            LHI 'M13
02 065 106 032 002        CAL PRINT
02 070 106 264 002        CAL LEA
02 073 016 001     PNCH,   LBI 1
02 075 301         ST1,    LA B
02 076 106 022 002        CAL SEND
02 101 301                LA B
02 102 054 377            XRI 377         /COMPLEMENT DATA
02 104 106 022 002        CAL SEND
02 107 301                LA B
02 110 074 000            CPI 0           /0 PUNCHED?
02 112 150 121 002        JTZ ST11
02 115 010                INB
02 116 104 075 002        JMP ST1
02 121 106 264 002 ST11,   CAL LEA
02 124 104 144 002        JMP  WAIT       /BYPASS M14 MESSAGE
                   /
                   /
                   /*****READER TEST TAPE EXERCISE********
                   /
02 127 106 371 001 TSTTP,  CAL CRLF
02 132 106 371 001        CAL CRLF        /READ TEST TAPE
02 135 066 305            LLI M14         /MESSAGE
02 137 056 003            LHI 'M14
02 141 106 032 002        CAL PRINT
02 144 103         WAIT,   INP SEL1
02 145 032                RAR
02 146 100 144 002        JFC WAIT
02 151 101                INP SEL0
02 152 106 235 002 ST2,    CAL RED1       / READ CHAR
02 155 074 000            CPI 0
02 157 150 152 002        JTZ ST2
02 162 016 001            LBI 1           /INITIAL DATA
02 164 271         ST3,    CP B
02 165 112 251 002        CFZ PE          /PRINT ERROR
02 170 301                LA B
02 171 054 377            XRI 377         /COMPLEMENT DATA
02 173 310                LB A
02 174 106 235 002        CAL RED1        /READ NEXT CHARACTER
02 177 271                CP B
02 200 112 251 002        CFZ PE
02 203 301                LA B
02 204 054 377            XRI 377         /COMPLEMENT AGAIN
02 206 310                LB A
```

```
02 207 074 000              CPI 0           /0 CHECKED?
02 211 150 223 002          JTZ ST4
02 214 010                  INB
02 215 106 235 002          CAL RED1
02 220 104 164 002          JMP ST3
02 223 107          ST4,     INP SEL3        / SW 7 SET?
02 224 022                  RAL
02 225 140 152 002          JTC ST2         /YES: CONTINUE READ
02 230 022                  RAL             /SW 6 SET?
02 231 140 073 002          JTC PNCH        /YES: CONTINUE PUNCH
02 234 377                  HLT             /NO: STOP
                    /
                    /----CHARACTER READ SUBROUTINE----------
                    /
02 235 006 001      RED1,    LAI 1
02 237 123                  OUT SEL9
02 240 103          RED2,    INP SEL1
02 241 032                  RAR
02 242 100 240 002          JFC RED2
02 245 250                  XR A
02 246 123                  OUT SEL9
02 247 101                  INP SEL0
02 250 007                  RET
                    /
02 251 106 277 002  PE,      CAL RPRT
02 254 301                  LA B
02 255 106 277 002          CAL RPRT
02 260 106 371 001          CAL CRLF
02 263 007                  RET
                    /
                    /----PUNCH LEADER SUBROUTINE----------
                    /
02 264 016 100      LEA,     LBI 100         /LEADER AMT
02 266 250          LED,    XR A            /CLEAR A
02 267 106 022 002          CAL SEND        /PUNCH
02 272 011                  DCB
02 273 110 266 002          JFZ LED /B=0 GO TO PUNCH
02 276 007                  RET
                    /
                    /-----ARRANGE & SEND SUBROUTINE----------
                    /
02 277 340          RPRT,   LE A            /ARRANGE AND SEND
02 300 006 240              LAI 240         /SEND SPACE CHARACTER
02 302 106 022 002          CAL SEND
02 305 304                  LA E
02 306 002                  RLC             /POSITION FIRST CHARACTER
02 307 002                  RLC
02 310 340                  LE A
02 311 044 003              NDI 3
02 313 106 330 002          CAL RSND1       /PRINT IT
02 316 106 321 002          CAL RSEND       /2ND DIGIT
                    /
02 321 304          RSEND,  LA E            /GET ROTATED #
02 322 002                  RLC             /POSITION DIGIT
02 323 002                  RLC
02 324 002                  RLC
02 325 340                  LE A
02 326 044 007              NDI 7           /MASK IT
                    /
02 330 004 260      RSND1,  ADI 260        / CONVERT TO ASCII
```

```
02 332 106 022 002          CAL SEND        /PRINT IT
02 335 007                  RET
                            /
                            /******THE FOLLOWING ARE MESSAGE CHARACTER STRINGS***
                            /
02 336 103                  M1,   TEXT 11 CR TEST
02 337 122
02 340 040
02 341 124
02 342 105
02 343 123
02 344 124
02 345 015
02 346 012
02 347 000                  END     /TERMINATE MESSAGE WITH ZERO
                            /
02 350 114                  M2,   TEXT 11 LF TEST
02 351 106
02 352 040
02 353 124
02 354 105
02 355 123
02 356 124
02 357 015
02 360 012
02 361 000                  END
                            /
02 362 120                  M3,   TEXT 14 PRINT TEST
02 363 122
02 364 111
02 365 116
02 366 124
02 367 040
02 370 124
02 371 105
02 372 123
02 373 124
02 374 015
02 375 012
02 376 000                  END
                            /
02 377 123                  M4,   TEXT 17 SWIRL PATTERN
03 000 127
03 001 111
03 002 122
03 003 114
03 004 040
03 005 120
03 006 101
03 007 124
03 010 124
03 011 105
03 012 122
03 013 116
03 014 015
03 015 012
03 016 000                  END
                            /
03 017 117                  M5,   TEXT 21 OVER-PRINT TEST
03 020 126
```

```
03 021 105
03 022 122
03 023 055
03 024 120
03 025 122
03 026 111
03 027 116
03 030 124
03 031 040
03 032 124
03 033 105
03 034 123
03 035 124
03 036 015
03 037 012
03 040 000          END
                    /
03 041 123          M6,  TEXT 14 SPACE TEST
03 042 120
03 043 101
03 044 103
03 045 105
03 046 040
03 047 124
03 050 105
03 051 123
03 052 124
03 053 015
03 054 012
03 055 000          END
                    /
03 056 105          M7,  TEXT 31 ECHO TEST (HIT ANY KEY)
03 057 103
03 060 110
03 061 117
03 062 040
03 063 124
03 064 105
03 065 123
03 066 124
03 067 040
03 070 050
03 071 110
03 072 111
03 073 124
03 074 040
03 075 101
03 076 116
03 077 131
03 100 040
03 101 113
03 102 105
03 103 131
03 104 051
03 105 015
03 106 012
03 107 000          END
                    /
03 110 114          M8, TEXT 53 LINE ECHO TEST (TYPE UP TO 70 CHARACTERS)

03 111 111
```

```
03 112 116
03 113 105
03 114 040
03 115 105
03 116 103
03 117 110
03 120 117
03 121 040
03 122 124
03 123 105
03 124 123
03 125 124
03 126 040
03 127 050
03 130 124
03 131 131
03 132 120
03 133 105
03 134 040
03 135 125
03 136 120
03 137 040
03 140 124
03 141 117
03 142 040
03 143 067
03 144 060
03 145 040
03 146 103
03 147 110
03 150 101
03 151 122
03 152 101
03 153 103
03 154 124
03 155 105
03 156 122
03 157 123
03 160 051
03 161 015
03 162 012
03 163 000

03 164 101
03 165 114
03 166 124
03 167 105
03 170 122
03 171 116
03 172 101
03 173 124
03 174 105
03 175 040
03 176 103
03 177 110
03 200 101
03 201 122
03 202 101
03 203 103
03 204 124
```

```
END
/
M9,   TEXT 32 ALTERNATE CHARACTER TEST
```

```
03 205 105
03 206 122
03 207 040
03 210 124
03 211 105
03 212 123
03 213 124
03 214 015
03 215 012
03 216 000          END
                    /
03 217 105          M10,  TEXT 15 ERROR, ASCII=
03 220 122
03 221 122
03 222 117
03 223 122
03 224 054
03 225 040
03 226 101
03 227 123
03 230 103
03 231 111
03 232 111
03 233 075
03 234 000          END
                    /
03 235 127          M11,  TEXT 14 WORSE CASE
03 236 117
03 237 122
03 240 123
03 241 105
03 242 040
03 243 103
03 244 101
03 245 123
03 246 105
03 247 015
03 250 012
03 251 000          END
                    /
03 252 047          M12,  TEXT 10 '_W/'_W/
03 253 137
03 254 127
03 255 057
03 256 047
03 257 137
03 260 127
03 261 057
03 262 000          END
                    /
03 263 120          M13,  TEXT 21 PUNCH/READ TAPE
03 264 125
03 265 116
03 266 103
03 267 110
03 270 057
03 271 122
03 272 105
03 273 101
03 274 104
```

```
03 275 040
03 276 124
03 277 101
03 300 120
03 301 105
03 302 015
03 303 012
03 304 000          END
                    /
03 305 122          M14,    TEXT 20 READ TEST TAPE
03 306 105
03 307 101
03 310 104
03 311 040
03 312 124
03 313 105
03 314 123
03 315 124
03 316 040
03 317 124
03 320 101
03 321 120
03 322 105
03 323 015
03 324 012
03 325 000          END
                    /
                    $
```

APPENDIX B

MICROCOMPUTER TELETYPE EXERCISER OPERATING INSTRUCTIONS

I. General (See Figure B-1)

A. Down position of microcomputer switches is the logical "Ø" position.

B. "Intrpt. Clock" and "Single Cycle" switches should be in down position.

C. Toggle switches should be set to "Single Address" and "Run".

D. The keyboard buttons and the "Address" switches are not used for teletype exercising.

E. Once a test is started, it can be stopped by depressing "Reset".

F. Numbers given for "Data 1" and "Data 2" switches are octal.

G. For microcomputer startup, plug in *Teletype*, turn on microcomputer, depress "Reset," and turn *Teletype* to "On-Line."

H. The microcomputer operates *Teletype* with a 20-mA loop.

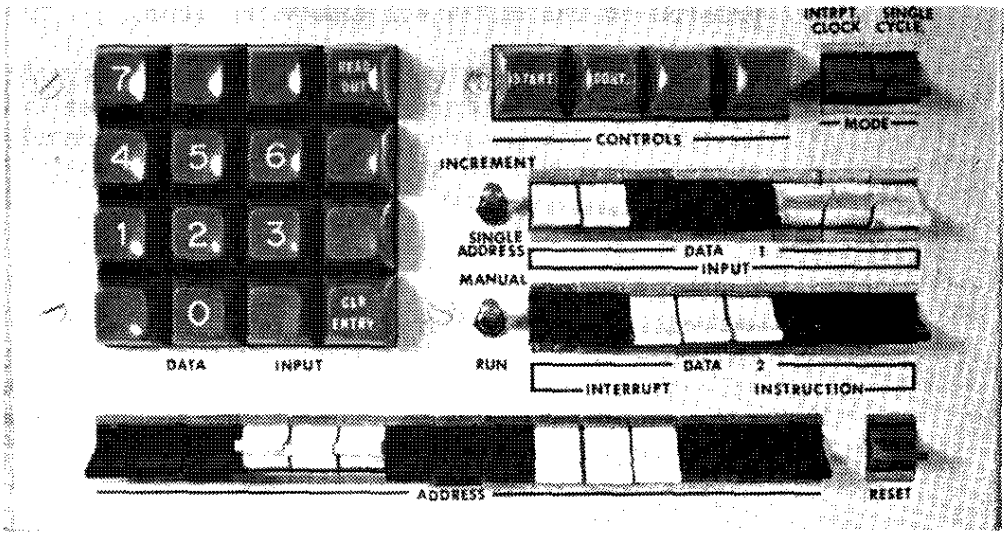

Figure B-1. Desk-Top Microcomputer Controls

II. Tests Operation and Description

A. CARRIAGE RETURN TEST (CR TEST), LINE FEED TEST (LF TEST), OVER-PRINT TEST, and SPACE TEST (SP TEST).

These four tests are run sequentially and are started as follows:

1. Set "Data 2" switches to 015. Depress "Start."

B. SWIRL PATTERN TEST and WORST CASE TEST (worst case for ASR/KSR-33) are run sequentially as follows:

1. Set "Data 2" switches to 025. Depress "Start."

2. WORST CASE can be run separately by setting "Data 2" switches to 045.

C. CHARACTER ECHO TEST, LINE ECHO TEST, and ALTERNATE CHARACTER TEST

1. Set "Data 2" switches to 035. Depress "Start." The CHARACTER ECHO TEST is started. When any key (except "Delete" or "Rub Out") is typed, the computer will echo the ASCII Code for the key. Once "Delete" or "Rub Out" is depressed, the LINE ECHO TEST is started.

2. LINE ECHO works as follows: Type any string of characters, up to 70 characters. Type a "bell" (Control G); the line will be echoed from the computer. Type "Delete" or "Rub Out" to send the program to the ALTERNATE CHARACTER TEST.

3. When alternating between any two characters, the ASCII Code for an incorrectly read character will be typed. The program stays in this test until another sequence is started.

D. READER and PUNCH TESTS

1. PUNCH/READ TEST. Turn on punch. Set "Data 2" switches to 055. Depress "Start." A leader followed by 6 ft of test tape will be punched. Another leader will be punched at end of test tape and punching will halt. Put leader in the reader and turn on reader. Strike any key on keyboard; reader will start to verify the test tape. Turn off the punch. If an error is read, the *Teletype*

will type two sets of three octal numbers: what was read and what should have been on the tape. It can then be determined from the test tape whether the error was in the punch or reader. The test will stop after the pattern is read.

2. If "Data 1" switches are set to 100, the punch/read routine will continue automatically.

3. READ TEST TAPE. Load leader of test tape in reader. Turn on the reader. Set "Data 2" switches to 065. Depress "Start." If "Data 1" switches are 000, about 6 ft of test tape will be read and verified; the test will then halt. If "Data 1" switches are set to 200, test tape will be read to end; the test will be repeated approximately every 6 ft. Error printouts will occur when the tape gets to the trailing leader.

REFERENCES

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