SUDING OPERATING SYSTEM

Z-80 OPERATING SYSTEM For the Digital Group Z-80 CPU Card and 1024 Character TV Interface

General Design

This programming system provides five key programs and many supporting subroutines. The user is able to enter his programming, check out his programming, and finally run his programming under the control of these five included programs.

The first program is a cassette reading program, almost completely contained on the Eraseable Read Only Memory (EROM). A frequency shifting data cassette is converted from serial data to parallel data and loaded into memory. The default data rate is 1100 BPS, and the default start and stop addresses are 001 000 and 007 377 respectively.

The next program is a cassette writing program which allows storing the contents of memory on a low-cost audio cassette recorder. The default data rate and addresses are the same as for cassette reading.

A storage dump program uses the CRT readout board and a TV set to display several items necessary to ease programming. The 14 internal registers of the Z-80 CPU are interpreted and displayed exactly as they were immediately prior to calling the TV storage dump program. The two internal Z-80 status flags are also dumped and interpreted as are the stack pointer address and return address. The return address is only valid should the TV storage dump occur during a subroutine. The two 16 bit indeces are also dumped, as well as the I (Interrupt) and R (Refresh) registers. The current interrupt mode (0,1, or 2) is displayed also. The full contents of memory are then displayed, 128 bytes at a time. The initial address for each line is displayed at the left of each line, and 14 sequential bytes are displayed to the right The TV dump will be in Octal if option 3 is selected, or in Hex if option 4 is selected.

A keyboard programming capability allows entering octal code directly from the system keyboard. Programming may be entered at any available address, but programming below 006 000 runs the risk of destroying key portions of the operating system. The keyboard programming uses Octal if option 3 is selected. Option 4 allows Hex coding to be entered.

The final programming section is an operations monitor. The TV displays a list of up to ten options available to the user. The user then enters the number of the desired operation, and a table lookup selection performs a branch to the desired program.

Using the Digital Group Z-80 Operating System

Initial Cassette Read:

After turning on the microprocessor, the message "READ Z-80 INITIALIZE Cassette" will appear on the screen. Start the cassette recorder reading the cassette, and when the low tone begins, push the reset button and release. When data begins after the short tone leader, the TV will display the least significant digit of the octal page being currently loaded, byte by byte. Memory is checked byte by byte, and missing or defective memory addresses are indicated by a "." being printed instead of the page. When the tone stops, the operations monitor assumes control, and the program loops awaiting a keyboard entry of the desired selection.

Storage Dump and Keyboard Program

The typical first entry will be a request to view storage to find some free area where some additional user supplied programming may be placed. Pressing a "3" will result in a display of the registers, indeces, flags, and stack data in Octal. A "4" will produce a Hex display.

Press the Space Bar. You will notice an arrow at the top left pointing to byte 000000 presently. This pointer indicates the byte where programming might take place if desired (since 000000 is in read only memory, no change is possible.) This pointer may be preset by entering the page (H) and byte (L). Try entering H070 and then L123. Notice where the pointer has now moved to. Since this is RAM area in a 16K or greater system, the observed byte may be changed by entering the desired data. e.g. 321 could be entered from the keyboard. Notice the bottom line "scratchpad effect." The actual data is not entered at the indicated address until after the final entry. Emergency abort may be done by pressing the "reset key" on the system prior to the final entry, with no affect on memory. Of course, no effective programming entry is possible where no memory exists.

The cursor may be incrementally moved around the screen. The Digital Group keyboard with cursor control keys allows the user to move the pointer in the direction indicated by the cursor keys. Keyboards different from this one can move the pointer about if a control H, control J, control K, or control L is entered.

The system will return to the Op Sys by pressing an R or r on the keyboard.

Command Summary

Space - New memory display page
H 000 (HH) - Preset page (octal or hex)
L 000 (HH) - Preset byte (octal or hex)
R - Return to Op Sys
H CTRL - Move pointer backward
J CTRL - Move pointer down
K CTRL - Move pointer up
L CTRL - Move pointer forward
000 (HH) - Insert (octal or hex) code at indicated byte

Use care when entering code below 006 000. Since this is system area, any code or operations can result in an inoperative system with no means of recovery other than re-reading the cassette.

Cassette Write:

Once the desired programming has been entered, the user may wish to save it for later usage. The user is also advised to save all programming on cassette prior to initial execution to avoid potential programming self-destruction. If self-destruction upon execution occurs, the program may be reloaded and suitable corrections made.

Insert a cassette and start the recorder in record mode. After making sure that the leader on the cassette has passed by the record head, enter a "2" while in the Operations Monitor. The TV will display the message "Writing" until the cassette recording operation is finished about 1/2 minute later, then return to the Operations Monitor. Turn off the recorder, and you have the system and the added programming on the cassette.

Cassette Read:

Cassettes may be read by pressing "1" while in the Operations Monitor, or they can be read when power is applied.

Panic Button:

Pressing the reset button will always return the user to the initial cassette load, or Operations Monitor.

Fine Points of the Z-80 Operating System:

Memory Extent:

The Z-80 Operating System is designed to occupy the lower 1.5K of the Z-80 CPU System. The default read and write high address is preset to 2K. However, the cassettes may be any length up to 64K, but at the read/write speed of 100 bytes per second, the cassette should be no longer than required.

If you have greater than 2K of memory on your system, modify the data at 001 052 (byte) and 001 055 (page) to reflect the memory extent desired on the cassette. Example: You have 10K of Z-80 system, and you wish to write 4K worth of programming. Since the octal equivalent of 4K is 017377, enter 377 at 001 052 and 017 at 001055. The default address is now set to 017 377. The cassette read programming will be automatically modified by the cassette. Cassettes of varying lengths may be interchangeably read with no operator intervention eg. 2K, 32K, 13K, 20K, etc.

Data Rate:

RAM address 001 027 contains the timing loop constant which controls the resultant cassette baud rate. The normal constant is 037, which results in 1100 baud.

Storage Dump:

The initial page of the TV dump which displays and interprets the registers, flags, and stack pointers can be the most useful part of the whole system when faced with a confusing software problem. Insert an unconditional branch to 003 000 in place of the byte following the point in question. This will display and interpret the registers and flags, generally giving a much better picture of what is happening in that "insolvable problem". Another technique is to use the "Restart 6" as a branch. This then involves inserting a single "367" byte. The "Restart 6" must then be vectored forward to 003 000. The software Operating System cassette included has this feature included, so you may get a storage dump by merely inserting a "367" in your programming.

Interrupts/Restarts 1-7:

The Z-80 has eight restart or interrupt addresses at the low end of storage normally occupied by a ROM to give a power on and go capability. The EROM provided in the Digital Group kits vectors Restarts 1-7 through the EROM to the beginning of Page 001 as shown in the software listings. The user may now vector forward these interrupt/restarts as desired, but interrupt level programming is best left to the experts. Restart 7 has the lowest level priority on the Z-80 CPU board system. NMI also enters in the EROM area, and is vectored forward to address 1035.

Interrupt/Restart Ø:

The Reset function on the Z-80 will force programming to begin at address 000 000, as does restart Ø ("307"). The Reset is used to control the Operations Monitor and the initial cassette read operation. It also has the highest priority of the eight interrupts. The EROM has control of Reset/Restart Ø and finally branches it forward to address 005 000 where the Operations Monitor resides.

Operations Monitor:

Page 005 of the Z-80 Operating System is dedicated to aiding the user to make his program selections. The title area uses bytes 005 124 through 005 377. Up to 10 (0-9) different program start locations may be specified by putting the high and low addresses at the proper place between 005 100 and 005 123.

The user can title his program by inserting the ASCII characters desired in the format required. Here is the secret: A special subroutine called TV Editor controls the messages displayed on the TV screen. This subroutine is entered from the Operations Monitor to put the message on the TV. Address 005 227 - 005 377 (and into page 6 if needed) can be used to enter a set of titles in a special machine code. "377" = Erase the screen, "376" - "200" are ASCII characters, "177" - "001" are the octal number of spaces, and "000" means the end of the message.

Example: You wish to add "7 Go" to the Operations Monitor message.

Address	Data	Explanation
005 227	063	Insert 51 blanks from last character
005 230	267	"7"
005 231	240	Space
005 232	307	"G"
005 233	357	"o"
005 234	000	End of message.

The program routine portion of the Operations Monitor is located between 005 100 and 005 123 as shown by the listings. The byte portion of the branch address is placed on the even address boundary, and the page portion on the odd address.

Example: You have designed the above program "Go" to execute from address 006 000. Since you also wish to branch to "Go" from a "7" entry when in the Operations Monitor, place an "000" at address 005 116 and an "006" at address 005 117.

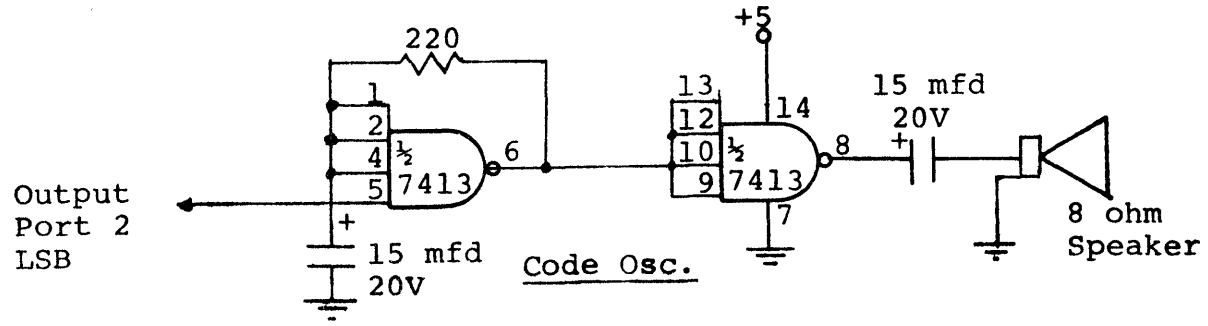
Typing a "7" when in the Operations Monitor will now result in execution of "Go".

Digital Group Z-80 Distribution Cassette

The included cassette contains the Z-80 Operating System program plus 5 other demonstration or diagnostic programs, all of which will operate in a 2K or larger system.

The Z-80 Operating System program is described separately.

A second program included is a computerized Amateur Radio (Ham) demonstration. This cassette contains a "CW Keyboard" routine and a "RTTY Receive" routine. After loading, entering a "5" will cause a branch to the "CW Keyboard" routine. A special page then requests the desired output CW speed. After entering a 1,2, or 3, the operator may then enter the desired message to be translated into code. Besides being outputted via the LSB of Output Port 2, the TV monitor will display the message as it is entered. A 256 character software FIFO allows typing up to 256 characters ahead of the actual CW character being outputted. A different speed or a new program may be requested by pressing the "Reset/Start" switch. The output is a "1" TTL level equals keydown. A quick and dirty code oscillator shown below can be used to demonstrate the program.



Another routine included in the "Ham Demo" is a RTTY receive routine which converts Frequency shifted 60 WPM Baudot to ASCII and displays the characters on the TV Monitor. Three lookup tables are used, which result in Upper Case, Lower Case, or the Greek letter equivalents to the English letters. These Output formats are selected by options 6,7, or 8 respectively. The RTTY is inputted to the Digital Group Z-80 Op System via the cassette interface. The 2125/2975 shift of the cassette is equal to the wide shift frequencies of Ham RTTY. The output of the short wave receiver may simply be connected to the cassette cable used for reading data from the cassette. Since few stations use wide shift any more, a simple modification to the cassette interface allows its use as a terminal unit. Modify the 2975 Active Filter of the Cassette Interface to Narrow Shift tone generally used on Ham RTTY now. I would suggest a switch mounted conveniently somewhere to select 2975/2295. Be sure to return the switch to 2975 for normal cassette operations. See July '76 Byte for further details. A more advanced version using full screen capabilities will be available for use with the Digital Group "Hamboard".
This set of routines does not have attached read, write, dump, and program routines. To start up other programs, you will have to power down, then turn on the power for normal cassette initialize restart operation. Pressing "Reset/Start" will permit respecifying the routines in this demo program.

Another demonstration program included is one which synthesizes music. This program plays the Star Spangled Banner while it prints the US Flag on the TV monitor (So what else for the Bicentennial?)

The various data paths of the Digital Group Z-80 CPU card have resonant frequencies. By frequency modulating these data paths with different timing loops, music results. Play the programmed music by setting an AM radio tuned to around 1250 KHz on top of the CPU card. Slightly varying the tuning as well as the placement will result in the best tone. You may replay by pressing any keyboard key except "R" or "r". These keys will reset into the Operations Monitor.

This program also does not have the usual routines, so to start up other programs, you will have to power down, then turn on power for normal cassette initialize/restart operations.

The next program following a 5 second interval is a computer game called "Brain Teaser".

Game Example - Brain Teaser

This puzzle uses a three by three matrix. Each of the nine board positions must contain either 0 or 1. The object is to manipulate the patterns of 0's and 1's until a pattern is obtained that contains a 0 in the center position and 1's in all other positions. To change the board pattern you must choose a square by entering the square's position number according to the following diagram:

```
1 2 3
4 5 6
7 8 9
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You may only select a square that contains a 1. Choosing a square in the center of an edge causes all positions along that edge to change state. (0's become 1's and 1's become 0's.) Choosing a corner square causes the corner square and the three adjacent squares to change state. Choosing the center square causes all squares to change state except for the four corner squares.

At the beginning of each game the microprocessor picks a random board pattern that contains either one or two 1's. Limiting the number of 1's to two assures that reaching the winning pattern will require at least 6 moves. The most difficult pattern requires only eleven moves if the proper square is always chosen. An all zero pattern loses.

Not only is the board pattern displayed on the TV, but also the move number. Press "Reset/Start" to replay. Power off, then back on to run other routines.

Memory Tests

Three Z-80 Memory Test Routines have been written to allow the operator to initially or periodically test the memory chips in his system. The first routine checks the system memory and prints out the extent of the contiguous groups of memory. This routine checks for proper memory jumpering. The second routine generates a randomized pattern throughout memory and then reads back and compares for identical data patterns. This test checks for bad IC's, unsoldered pins, and shorted address pins. The third routine progressively writes a short subroutine through memory and then executes the subroutine. This routine checks for slow memory. The routines check various Op/System areas and require that the Three-Part Memory Test Program be reloaded to rerun a routine or to run another routine. The bottom 1K of memory is not tested by these routines.

ROUTINE 1

After the Three-Part Memory Test Program has been loaded, press option "1" on the keyboard. The TV will momentarily blank while the system analyzes the amount of memory presently on the system. The result will then appear on the screen as octal address range(s). If the memory has problems, the display may indicate a large number of contiguous good areas of memory. The user should then correct the situation by running Routine 2 to discover the problem. After the user fixes the problem, he should then re-run Routine 1. The memory extent results must exactly match your intended jumper and memory mapping plans or your software needs. Non-match, resulting in either missing memory areas or memory overlapped, will cause very misleading programming errors.

ROUTINE 2

Press option "2" after loading (or reloading) the Three-Part Memory Test Program. The system will display an asterisk in the upper left corner of the screen while the first random pattern is being written into memory. The system then clears the asterisk and begins displaying Octal addresses in the upper left corner of the TV. The addresses are those memory locations that have checked "ok" so far on this run. When memory locations without memory are located, the last valid address will be displayed for a few seconds (or fractions of a minute) until more memory is located. If all tests "ok", an alpha (α) is displayed on the TV and a new random pattern is loaded into memory.

Several problems can be found through this test. Bad IC's will have their board number and IC location printed on the screen. Your CPU or 8K memory board construction guide's component layout will then direct you to the offending memory IC. The memory "Bank" numbers are:

Bank Ø = 0K - 8K
1 = 8K - 16K
etc.
7 = 56K - 64K

When an IC is indicated as "bad", first check for unsoldered socket pins and bent leads; then suspect the IC and socket.

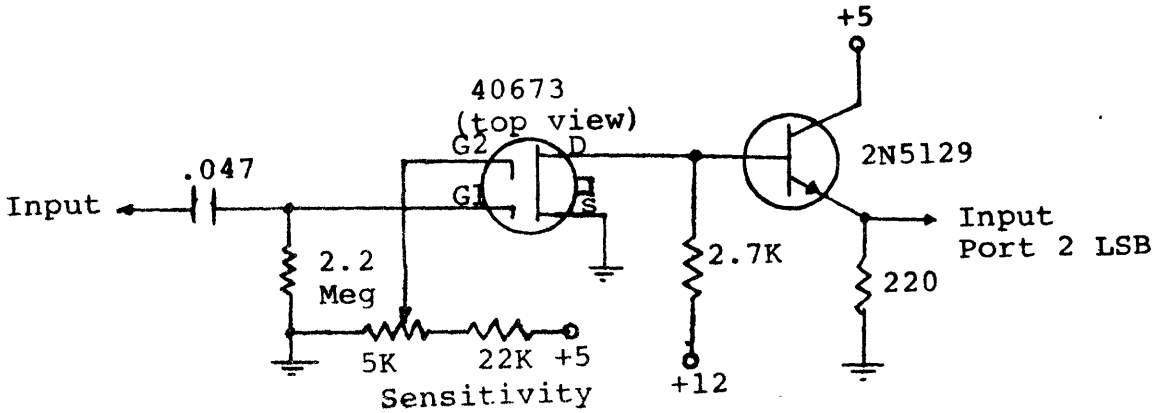
The memory test address incrementing may suddenly stop incrementing even though more contiguous memory is available. This is most often caused by shorted address lines or an address line shorted to a data line. The last successful address displayed will give a hint as to the most probable line to inspect. Scoping the address lines of the failing board generally shows one or more address lines failing to reach proper TTL levels (Ø level ≃.4 volts; 1 level ≃3 volts). Better, the next address (failing address) may be analyzed for what the new bit would be and only that line be inspected. Another problem that can cause a premature test failure is a very slow memory.

ROUTINE 3

The most critical memory access speed requirement occurs during the use of memory for programming rather than data retrieval. This time, after loading the Three-Part Memory Test Program, select Option "3". Again, the screen will display a running address display. Only addresses contiguous from byte Ø can be tested by this routine. A successful test will display an alpha (α) on the screen and begin the test again. If slow memory is encountered, the system may develop a "software runaway" condition but the TV will display the last lower good area address. The actual failing address may be Ø - 5Ø bytes further into memory since the executing subroutine may have failed on any of the various instructions within the subroutine.

Successfully running Test 2 and/or Test 3 for >30 minutes without failure has always indicated good memory (assuming no intermittents and temperature fallouts). Running these tests every few months (or weeks) will provide an excellent preventative maintenance check on system performance. Visitors are always amazed when you ask them to point to any memory IC (other than the bottom 2K) and after you pull it out (or bend out an address pin), the Test finds the offending IC.

The final routine is a programmed 15 Hz - 10 KHz frequency counter. This is made possible by the fact that the Digital Group's CPU card uses a crystal to precisely control the cycle times. After sampling an audio signal from Input Port 2, LSB, for 1/2 second, the number of 1/2 cycles occurring are displayed on the TV Monitor. This routine could be used to check the frequency of the cassette's VCO if desired. Since the input port requires a TTL compatible level input, some form of signal conditioning is generally required. Many different counter input circuits of varying sophistication and quality are useable, but the simple circuit shown below should work adequately for most purposes. Precise trimming of the counter is accomplished by varying the timing value at 6244 (LSB) and 6245 (MSB).



Some suggested practice programs for those new to a Z-80 Microprocessor:

1. Clear the screen and write an "A":

Address	Data	Explanation
006 000	315	Call the subroutine "Home Erase".
006 001	346	
006 002	000	
006 003	076	Load the Accumulator with the ASCII code for "A".
006 004	301	
006 005	315	Print the "A" on the screen
006 006	372	
006 007	000	
006 010	166	Halt and rejoice!
005 116	000	Modify the Operations Monitor to execute the above program at 006 000.
005 117	006	

Push "Reset" and then typing a "7" should run the program. Push "Reset" to return to the Operations Monitor after execution.

2. Modify the above program to print an "a".

3. Print your name.

4. Print your name in the middle of the screen using "TV Editor".

5. Print your name in the middle of the screen, Flashing on and off. (Hint - Use two "Seconds" subroutines and an unconditional branch to program beginning loop).

6. Print only the 128 possible characters on the screen and stop, using less than 20 bytes (Hint - Load Accum, Save, Print, Restore and Modify, loop not end).

Score: Over 100 bytes = HA!
Over 30 bytes = Fair
20-25 bytes = Good
15-19 bytes = Giant
(Can be done in 11 bytes or less)

Subroutines you may wish to call for your own programming:

Subroutine	Address	Operation and Comments
TV	000 372	Prints a character on the TV through the Digital Group CRT readout attached to Port Ø. Load accumulator with character prior to calling. Accumulator returned cleared to "000".
Space	000 370	Prints a space (blank position) on the TV. Accumulator need not be present. Accumulator will return cleared.
Home Erase	000 346	Prints 1024 spaces on the TV, with the cursor set so that the next character entry will appear at the upper left of the screen. Accumulator, B, and C are cleared at end.
TV Editor	002 000	Previously described during Operations Monitor Operation. Preset H & L regs to address of initial byte of the message prior to calling. Accumulator, B, C, E, H & L are cleared or changed when subroutine ends.
Keyboard	001 250	This subroutine loops until an MSB keypressed strobe bit goes high. The program enters another loop until the MSB returns to low level. The Accumulator will have the input character.
Octal Character	001 267	TV Storage Dump and Keyboard Program use this subroutine to produce three numbers on the TV representing the octal notation of an 8 bit byte. The desired byte is loaded into the E register. The octal characters will be printed and only the accumulator returned cleared.
Hex Character	002 041	Same as above, only Hex results.
ASCII - Octal Conv	004 246	This subroutine allows the operator to enter three numbers (left to right) indicating the octal representation on an 8 bit byte. The numbers are displayed on the TV when entered. The Accumulator will contain the data byte. The B&C registers are returned cleared. 001 247 must be set to 000.
ASCII - Hex Conv	Hex 04A6	As above, only Hex is used if Hex 01A7 contains a Hex C8.
1/10 Seconds	001 173	Preset Accumulator to the number of 1/10 seconds to elapse before returning. Accumulator, C, and D registers are cleared.

NOTE: 40673 available from: Circuit Specialists, Box 3047, Scottsdale, Arizona 85257 for $1.65 including shipping.

This set of software is provided without listings so that users may have low cost (the major expense of software is documentation) programs which are simple yet powerful demonstrations of the Digital Group's Microprocessor Systems. We hope that the software giants among you will not be unduly offended by the lack of a hardcopy.

We would suggest that you be very careful with the cassette, since it represents the sole means by which you can run your system. The cassette may be duplicated for backup by using two cassette recorders, although some quality degradation will result. The major programs of "Z-80 Op Sys", "Memory Test", and "Frequency Counter" may be system duplicated via their included "Write Cassette" routine. Separate duplicate copies of this cassette and operation guide are available postpaid USA from the Digital Group for $10.00. Order #Z-80 Op Sys Cassette for 1024 TVC.

This cassette was made using a 16K Digital Group Z-80 System into a Superscope C-104 cassette recorder. Every cassette is individually played back into the system under marginal conditions and checked for a perfect tape byte/bit count.

Dr. Robert Suding

1702 Prom Pattern (ZE)

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ØØØØØØ  3Ø3  Ø63  ØØØ JP      ØØØØ63    (Reset/Jump to Restart Ø)
ØØØØØ3  322           R
ØØØØØ4  345           e
ØØØØØ5  341           a
ØØØØØ6  344           d
ØØØØØ7  24Ø           (Space)
ØØØ1Ø  3Ø3  ØØ2  ØØ1 JP      ØØ1ØØ2    (Jump to Restart 1)
ØØØ13  332           Z
ØØØ14  255           -
ØØØ15  27Ø           8
ØØØ16  26Ø           Ø
ØØØ17  24Ø           (Space)
ØØØ2Ø  3Ø3  ØØ5  ØØ1 JP      ØØ1ØØ5    (Jump to Restart 2)
ØØØ23  311           I
ØØØ24  316           N
ØØØ25  311           I
ØØØ26  324           T
ØØØ27  311           I
ØØØ3Ø  3Ø3  Ø1Ø  ØØ1 JP      ØØ1Ø1Ø    (Jump to Restart 3)
ØØØ33  3Ø1           A
ØØØ34  314           L
ØØØ35  311           I
ØØØ36  332           Z
ØØØ37  3Ø5           E
ØØØ4Ø  3Ø3  Ø13  ØØ1 JP      ØØ1Ø13    (Jump to Restart 4)
ØØØ43  24Ø           (Space)
ØØØ44  3Ø3           C
ØØØ45  341           a
ØØØ46  363           s
ØØØ47  363           s
ØØØ5Ø  3Ø3  Ø16  ØØ1 JP      ØØ1Ø16    (Jump to Restart 5)
ØØØ53  345           e
ØØØ54  364           t
ØØØ55  364           t
ØØØ56  345           e
ØØØ57  24Ø           (Space)
ØØØ6Ø  3Ø3  Ø21  ØØ1 JP      ØØ1Ø21    (Jump to Restart 6)
ØØØ63  Ø41  ØØØ  ØØ1 LD      HL,ØØ1ØØØ Set RAM pointer
ØØØ66  Ø3Ø  ØØ3      JR      ØØ3       *ØØØØ73*
ØØØ7Ø  3Ø3  Ø24  ØØ1 JP      ØØ1Ø24    (Jump to Restart 7)
ØØØ73  176           LD      A,(HL)    Get Data
ØØØ74  376  123      CP      123       Is is a 123?
ØØØ76  Ø4Ø  ØØ7      JR      NZ,ØØ7    *ØØØ1Ø7*
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ØØØ1ØØ  Ø54           INC     L          Next Address
ØØØ1Ø1  176           LD      A,(HL)
ØØØ1Ø2  376  123      CP      123        Is it a 123 too?
ØØØ1Ø4  312  ØØØ  ØØ5  JP      Z,ØØ5ØØØ   Already initialized
ØØØ1Ø7  Ø61  ØØØ  ØØ2  LD      SP,ØØ2ØØØ  Set Stack Pointer
ØØØ112  315  346  ØØØ  CALL    ØØØ346     Erase TV
ØØØ115  Ø41  ØØ3  ØØØ  LD      HL,ØØØØØ3  Load Message Pointer
ØØØ12Ø  ØØ6  ØØ6       LD      B,ØØ6
ØØØ122  Ø16  ØØ5       LD      C,ØØ5
ØØØ124  176           LD      A,(HL)
ØØØ125  315  372  ØØØ  CALL    ØØØ372     Put Initialize Message on TV
ØØØ13Ø  Ø54           INC     L
ØØØ131  Ø15           DEC     C
ØØØ132  Ø4Ø  37Ø       JR      NZ,37Ø     *ØØØ124*
ØØØ134  Ø54           INC     L
ØØØ135  Ø54           INC     L
ØØØ136  Ø54           INC     L
ØØØ137  Ø2Ø  361       DJNZ    361        *ØØØ122*
ØØØ141  Ø41  Ø27  ØØ1  LD      HL,ØØ1Ø27  Set Cassette Constants
ØØØ144  Ø3Ø  ØØ3       JR      ØØ3        *ØØØ151*
ØØØ146  3Ø3  Ø35  ØØ1  JP      ØØ1Ø35     (Jump to NMI Routine)
ØØØ151  Ø66  Ø36       LD      (HL),Ø37   Set Speed Constant
ØØØ153  Ø54           INC     L
ØØØ154  Ø66  ØØØ       LD      (HL),ØØØ   Starting Byte
ØØØ156  Ø54           INC     L
ØØØ157  Ø66  ØØ1       LD      (HL),ØØ1   Starting Page
ØØØ161  Ø54           INC     L
ØØØ162  Ø66  377       LD      (HL),377   Ending Byte
ØØØ164  Ø54           INC     L
ØØØ165  Ø66  ØØ7       LD      (HL),ØØ7   Ending Page
ØØØ167  355  133
        Ø3Ø  ØØ1       LD      DE,(ØØ1Ø3Ø) Put Starting Address in DE
ØØØ173  315  234  ØØØ  CALL    ØØØ234     Read a Byte
ØØØ176  Ø2Ø  376       DJNZ    376        *ØØØ176* Delay to clear last data bit
ØØØ2ØØ  Ø22           LD      (DE),A     Put Data in Memory
ØØØ2Ø1  Ø32           LD      A,(DE)     Read Back Memory
ØØØ2Ø2  274           CP      H          Does Memory read correctly?
ØØØ2Ø3  172           LD      A,D
ØØØ2Ø4  Ø5Ø  ØØ4       JR      Z,ØØ4      *ØØØ212*
ØØØ2Ø6  Ø76  256       LD      A,256      Load "." if memory wrong
ØØØ21Ø  Ø3Ø  ØØ4       JR      ØØ4        *ØØØ216*
ØØØ212  346  ØØ7       AND     ØØ7        Otherwise convert address to ascii
ØØØ214  366  26Ø       OR      26Ø
ØØØ216  315  372  ØØØ  CALL    ØØØ372     Print on screen
ØØØ221  Ø52  Ø32  ØØ1  LD      HL,(ØØ1Ø32) Get Stop address
ØØØ224  Ø43           INC     HL
ØØØ255  Ø23           INC     DE
ØØØ226  355  122       SBC     HL,DE      Present & ending addresses same?
ØØØ23Ø  Ø4Ø  341       JR      NZ,341     *ØØØ173* Read more if not
ØØØ232  Ø3Ø  25Ø       JR      25Ø        *ØØØ1Ø4* Done, go to OP Sys Monitor
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ØØØ234  Ø56  Ø1Ø       LD      L,Ø1Ø      Read Byte Subroutine
ØØØ236  ØØ6  ØØ3       LD      B,ØØ3
ØØØ24Ø  333  ØØ1       IN      ØØ1        Get Cassette Data From Port 1,LSB
ØØØ242  313  1Ø7       BIT     Ø,A
ØØØ244  Ø4Ø  37Ø       JR      NZ,37Ø     *ØØØ236* Must have 3 valid start bit samples
ØØØ246  Ø2Ø  37Ø       DJNZ    37Ø        *ØØØ24Ø*
ØØØ25Ø  315  264  ØØØ  CALL    ØØØ264     Get Integrate Start subroutine
ØØØ253  14Ø             LD      H,B
ØØØ254  315  273  ØØØ  CALL    ØØØ273     Get an Integrated Bit
ØØØ257  Ø55              DEC     L
ØØØ26Ø  Ø4Ø  372         JR      NZ,372     *ØØØ254* Get the 8 bits
ØØØ262  1Ø1              LD      B,C
ØØØ263  311              RET
ØØØ264  Ø72  Ø27  ØØ1    LD      A,(ØØ1Ø27) Integrate the Start Bit
ØØØ267  326  ØØ6         SUB     ØØ6
ØØØ271  Ø3Ø  ØØ3         JR      ØØ3        *ØØØ276*
ØØØ273  Ø72  Ø27  ØØ1    LD      A,(ØØ1Ø27) Integrate each Data Bit
ØØØ276  1Ø7              LD      B,A
ØØØ277  Ø16  2ØØ         LD      C,2ØØ      Preset integration register
ØØØ3Ø1  333  ØØ1         IN      ØØ1        Get a sample from Port 1 LSB
ØØØ3Ø3  313  1Ø7         BIT     Ø,A
ØØØ3Ø5  3Ø2  314  ØØØ    JP      NZ,ØØØ314  Branch not a zero
ØØØ31Ø  Ø14              INC     C          Increment integration register
ØØØ311  3Ø3  32Ø  ØØØ    JP      ØØØ32Ø
ØØØ314  Ø15              DEC     C          Decrement integration register
ØØØ315  3Ø3  32Ø  ØØØ    JP      ØØØ32Ø
ØØØ32Ø  Ø2Ø  357         DJNZ    357        *ØØØ3Ø1* Get Another sample
ØØØ322  313  171         BIT     7,C        Is MSB of integration register Ø or 1?
ØØØ324  3Ø2  334  ØØØ    JP      NZ,ØØØ334
ØØØ327  Ø76  ØØ1         LD      A,ØØ1      If 1
ØØØ331  3Ø3  341  ØØØ    JP      ØØØ341
ØØØ334  Ø76  ØØØ         LD      A,ØØØ      If Ø
ØØØ336  3Ø3  341  ØØØ    JP      ØØØ341
ØØØ341  2Ø4              ADD     H          Add in the old bits
ØØØ342  Ø17              RRCA               Rotate Right
ØØØ343  147              LD      H,A        Update old bits register
ØØØ344  311              RET
ØØØ345  ØØØ              NOP
ØØØ346  Ø76  177         LD      A,177      Reset TV write cursor
ØØØ35Ø  315  372  ØØØ    CALL    ØØØ372
ØØØ353  ØØ6  ØØØ         LD      B,ØØØ      Erase 1Ø24 TV positions
ØØØ355  Ø16  ØØ4         LD      C,ØØ4
ØØØ357  315  37Ø  ØØØ    CALL    ØØØ37Ø     Call "Space" TV subroutine
ØØØ362  Ø15              DEC     C
ØØØ363  Ø4Ø  372         JR      NZ,372     *ØØØ357*
ØØØ365  Ø2Ø  366         DJNZ    366        *ØØØ355*
ØØØ367  311              RET
ØØØ37Ø  Ø76  24Ø         LD      A,24Ø      Clear one TV Space
ØØØ372  323  ØØØ         OUT     ØØØ        Output one TV Character
ØØØ374  257              XOR     A
ØØØ375  323  ØØØ         OUT     ØØØ
ØØØ377  311              RET
```
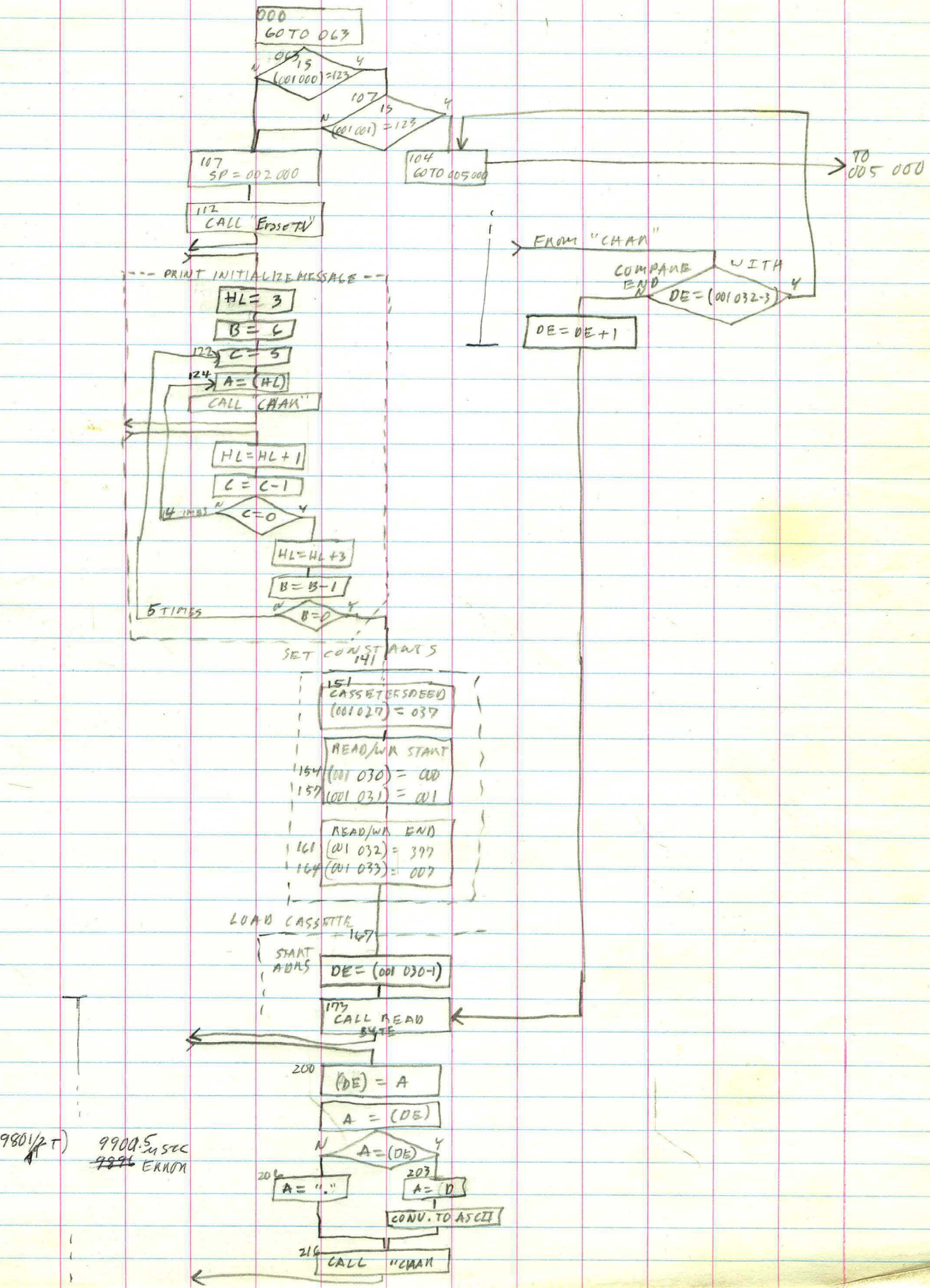

ZE ROM Flowchart

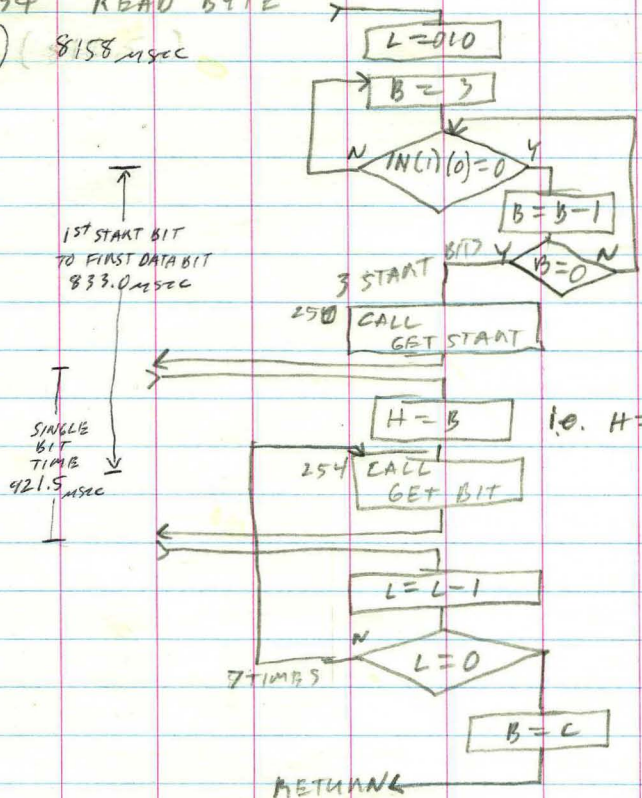


(19801/2T) 9900.5 μsec
~~9991~~ ERROR

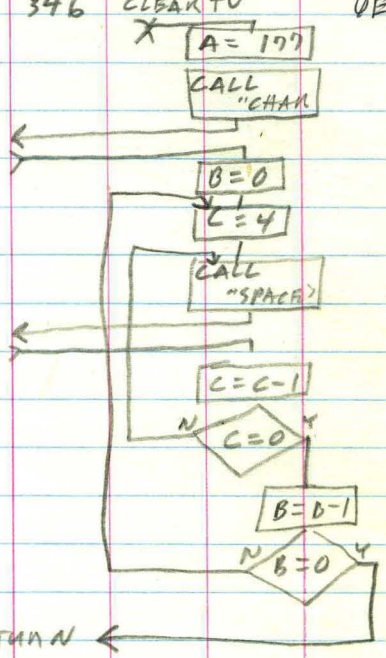
ZE ROM Subroutines

000 234 "READ BYTE"

(16 316 T) 8158 msec

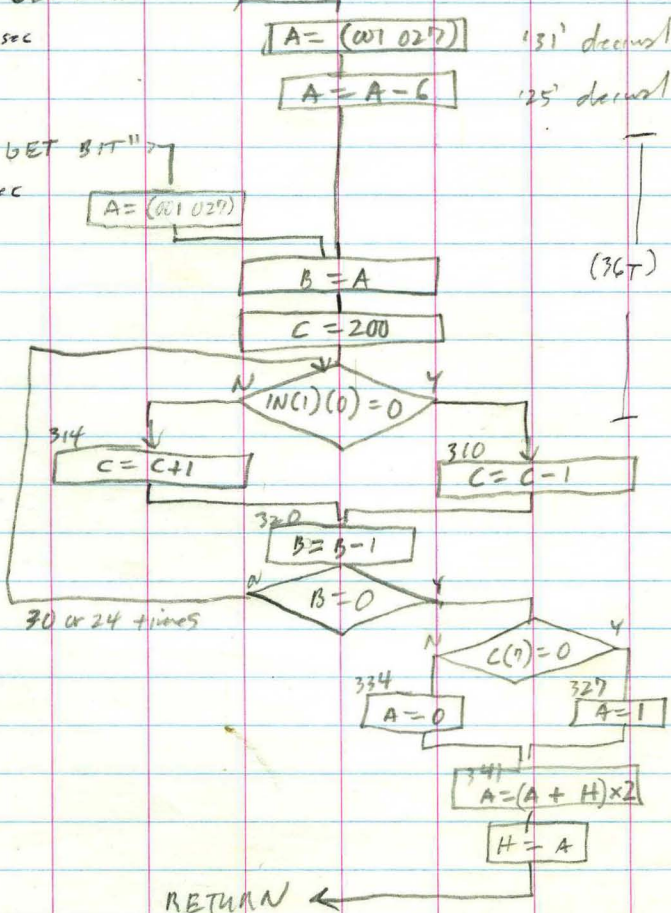


000 346 CLEAR TV 0E6



000 264 "GET START"

(1493 T) 746.5 msec



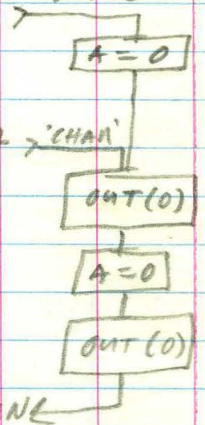
000 273 "GET BIT"

(1812 T) 906 msec

EACH ADDITIONAL UNIT @ 001027 ADDS 28 msec

(36 T) 18 msec

000 370 SPACE 0F8



00 372 'CHAR' 0FA

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	001 000	123		
	001 001	123		
	001 002	303		010 Restart
	001 003			
	001 004			
	001 005	303		020 Restart
	001 006			
	001 007			
	001 010	303		030 Restart
	001 011			
	001 012			
	001 013	303		040 Restart
	001 014			
	001 015			
	001 016	303		050 Restart
	001 017			
	001 020			
	001 021	303		060 Restart
	001 022			
	001 023			
	001 024	303		070 Restart
	001 025			
	001 026			
	001 027	037		Cassette Speed Constant
	001 030	000		L } Starting Addr
	001 031	001		H }
	001 032	377		L } Ending Address
	001 033	007		H }
	001 034			Reserved - Undefined
	001 035	303		NMI Restart
	001 036			
	001 037			
2K WRITE	001 040	041		Load L&H
	001 041	030		
	001 042	001		
	001 043	066		Store 000 @ 1030
	001 044	000		
	001 045	054		Inc L
	001 046	066		Store 001 @ 1031
	001 047	001		
	001 050	054		Inc L
	001 051	066		Store 377 @ 1032
	001 052	377		
	001 053	054		Inc L
	001 054	066		Store 007 @ 1033
	001 055	007		
	001 056	041		Load L&H
	001 057	214		(Write message area)
	001 060	001		

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	001 061	315		Call (TV Editor)
	001 062	000		
	001 063	002		
WRITE	001 064	076		Load A w 145
	001 065	145		(10 Seconds)
	001 066	323		Out 1
	001 067	001		(Mark tone Leader)
	001 070	315		Call (seconds)
	001 071	173		
	001 072	001		
	001 073	355		Load E&D w Start Addr
	001 074	133		
	001 075	030		
	001 076	001		
(1)	001 077	315		Call (Byte Write)
	001 100	124		
	001 101	001		
	001 102	052		Load L&H w M, Direct
	001 103	032		(Ending Address)
	001 104	001		
	001 105	043		Inc L&H
	001 106	023		Inc E&D
	001 107	257		Clear Carry Bit
	001 110	355		
	001 111	122		
	001 112	040		Jump Rel n Equal
	001 113	363		(1)
	001 114	076		Load A w 062
	001 115	062		
	001 116	315		Call (1/10 seconds)
	001 117	173		
	001 120	001		
	001 121	303		Jump Uncondx
	001 122	000		(Op Monitor)
	001 123	005		
BYTE WRITE	001 124	046		Load H w 011
	001 125	011		
	001 126	257		Clear A & Carry
	001 127	032		Load A w M, using E&D
	001 130	027		Rotate Left through Carry
(2)	001 131	323		Out 1
	001 132	001		
	001 133	315		Call (Time Delay)
	001 134	155		
	001 135	001		
	001 136	037		Rotate A Right
	001 137	045		Dec H
	001 140	040		Jump Rel n Zero

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	001 141	367		(2)
	001 142	076		Load A w 001
	001 143	001		
	001 144	323		Out 1
	001 145	001		
	001 146	315		Call (Time Delay)
	001 147	155		
	001 150	001		
	001 151	315		Call (Time Delay)
	001 152	155		
	001 153	001		
	001 154	311		Return
Time Delay	001 155	365		Push A
	001 156	072		Load A w M, Direct
	001 157	027		(Get Speed Const.)
	001 160	001		
	001 161	207		ADD A to A
	001 162	207		ADD A to A
	001 163	107		Load B w A
	001 164	345		Push H&L (Dummy Op)
(4)	001 165	000		NOP (Dummy Op)
	001 166	020		Dec B, Jump rel not zero
	001 167	375		(4)
	001 170	341		Pop H&L (Dummy Op)
	001 171	361		Pop A
	001 172	311		Return
(8)	001 173	026		Load D w 031
	001 174	031		
(7)	001 175	001		Load C&B
	001 176	003		
	001 177	000		
(5)	001 200	020		Dec B, Jump Rel not zero
	001 201	376		(5)
	001 202	015		Dec C
	001 203	040		Jump Rel n Zero
	001 204	373		(5)
	001 205	025		Dec D
	001 206	040		Jump Rel not Zero
	001 207	365		(7)
	001 210	075		Dec A
	001 211	040		Jump Rel not Zero
	001 212	360		(8)
	001 213	311		Return
	001 214	377		(Home Erase)
	001 215	134		(Spaces)
	001 216	327		W

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	001 217	362		r
	001 220	351		i
	001 221	364		t
	001 222	351		i
	001 223	356		n
	001 224	347		g
	001 225	000		(Return)
	001 226	076		Load A w "?"
	001 227	277		
	001 230	303		Jump Uncondx
	001 231	124		
	001 232	005		
	001 233	315		Call (Erase)
	001 234	346		A
	001 235	000		
	001 236	172		Ld A w D
	001 237	315		Call (TV)
	001 240	372		
	001 241	000		
	001 242	315		Call (ASCII)
	001 243	246		
	001 244	004		
	001 245	311		Return
	001 246	***		(Interrupt Level Indicator)
	001 247	***		(Octal/Hex Constant)
Keyboard	001 250	333		In Ø
	001 251	000		
	001 252	313		Test Bit 7,A
	001 253	177		
	001 254	050		Jump Rel if zero
	001 255	372		(keyboard)
	001 256	365		Push A
(10)	001 257	333		In Ø
	001 260	000		
	001 261	313		Test Bit 7,A
	001 262	177		
	001 263	040		Jump Rel not Zero
	001 264	372		(10)
	001 265	361		Pop A
	001 266	311		Return
Octal Char	001 267	173		Load A w E
	001 270	267		Or A w A
	001 271	036		Load E w 003
	001 272	003		
(11)	001 273	027		Rotate Left thru Carry
	001 274	027		"
	001 275	027		"
	001 276	365		Push A
	001 277	346		And A w 007

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	001 300	007		
	001 301	315		Call (ASCII TV)
	001 302	077		
	001 303	002		
	001 304	361		Pop A
	001 305	035		Dec E
	001 306	040		Jump Rel not Zero
	001 307	363		(11)
	001 310	311		Return
	001 311			
	001 312			
	001 313			
	001 314			
	001 315			
	001 316			
	001 317			
	001 320			
	001 321			
	001 322			
	001 323			
	001 324			
	001 325			
	001 326			
	001 327			
	001 330			
	001 331			
	001 332			
	001 333			User - Stack
	001 334			System - Stack
	001 335			
	001 336			
	001 337			
	001 340			
	001 341			
	001 342			
	001 343			
	001 344			
	001 345			
	001 346			
	001 347			
	001 350			
	001 351			
	001 352			
	001 353			
	001 354			
	001 344			Reserved for Stack
	001 356			
	001 357			
	001 360			
	001 361			

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	001 362			
	001 363			
	001 364			
	001 365			
	001 366			
	001 367			
	001 370			Reserved for Stack
	001 371			
	001 372			
	001 373			
	001 374			
	001 375			
	001 376			
	001 377			
TV Editor	002 000	176		Load A with Mem
	002 001	376		Compare A w "Home Erase"
	002 002	377		
	002 003	040		Jump Rel not Equal
	002 004	005		(1)
	002 005	315		Call (Erase)
	002 006	346		
	002 007	000		
	002 010	030		Jump Rel
	002 011	024		(2)
(1)	002 012	313		Test Bit 7,A
	002 013	177		
	002 014	050		Jump Rel if zero
	002 015	005		(3)
	002 016	315		Call (TV)
	002 017	372		
	002 020	000		
	002 021	030		Jump Rel
	002 022	013		(2)
(3)	002 023	376		Compare A with 000
	002 024	000		
	002 025	310		Return if equal
(4)	002 026	365		Push A
	002 027	315		Call (Space)
	002 030	370		
	002 031	000		
	002 032	361		Pop A
	002 033	075		Dec A
	002 034	040		Jump Rel not Zero
	002 035	370		(4)
(2)	002 036	043		Inc L&H
	002 037	030		Jump Rel
	002 040	337		(TV Editor)
HEX Char	002 041	315		Call (Space)

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	002 042	370		
	002 043	000		
	002 044	173		Load A w E
	002 045	017		Rotate Right
	002 046	017		"
	002 047	017		"
	002 050	017		"
	002 051	315		Call (Hex Out)
	002 052	061		
	002 053	002		
	002 054	173		Load A w E
	002 055	315		Call (Hex Out)
	002 056	061		
	002 057	002		
	002 060	311		Return
HEX Out	002 061	346		And A w 017
	002 062	017		
	002 063	376		Compare A w 012
	002 064	012		
	002 065	070		Jump Rel if less
	002 066	010		(6)
	002 067	326		Subtract 011
	002 070	011		
	002 071	366		Or A w 300
	002 072	300		
	002 073	315		Call (TV)
	002 074	372		
	002 075	000		
	002 076	311		Return
(6)	002 077	366		Or A w 260
	002 100	260		
	002 101	315		Call (TV)
	002 102	372		
	002 103	000		
	002 104	311		Return
	002 105	136		Load E w Mem
Character	002 106	072		Load A w Mem, Direct
	002 107	247		
	002 110	001		
	002 111	376		Compare A w "H"
	002 112	310		
	002 113	312		Jump if equal
	002 114	041		(Hex Char)
	002 115	002		
	002 116	303		Jump Uncondx
	002 117	267		(Octal Char)

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	002 120	001		
	002 121	377		(Home Erase)
	002 122	030		(Spaces)
	002 123	324		T
	002 124	326		V
	002 125	240		
	002 126	323		S
	002 127	324		T
	002 130	317		O
	002 131	322		R
	002 132	301		A
	002 133	307		G
	002 134	305		E
	002 135	240		
	002 136	304		D
	002 137	325		U
	002 140	315		M
	002 141	320		P
	002 142	051		(Spaces)
	002 143	322		R
	002 144	345		e
	002 145	347		g
	002 146	351		i
	002 147	363		s
	002 150	364		t
	002 151	345		e
	002 152	362		r
	002 153	363		s
	002 154	272		:
	002 155	071		(Spaces)
	002 156	301		A
	002 157	003		
	002 160	302		B
	002 161	003		
	002 162	303		C
	002 163	003		
	002 164	304		D
	002 165	003		
	002 166	305		E
	002 167	003		
	002 170	310		H
	002 171	003		
	002 172	314		L
	002 173	046		(Spaces)
	002 174	000		(Return)
	002 175	046		(Spaces)
	002 176	301		A
	002 177	247		'

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	002 200	002		
	002 201	302		B
	002 202	247		'
	002 203	002		
	002 204	303		C
	002 205	247		'
	002 206	002		
	002 207	304		D
	002 210	247		'
	002 211	002		
	002 212	305		E
	002 213	247		'
	002 214	002		
	002 215	310		H
	002 216	247		'
	002 217	002		
	002 220	314		L
	002 221	247		'
	002 222	045		(Spaces)
	002 223	000		(Return)
	002 224	143		(Spaces)
	002 225	306		F
	002 226	354		l
	002 227	341		a
	002 230	347		g
	002 231	363		s
	002 232	272		:
	002 233	074		(Spaces)
	002 234	323		S
	002 235	240		
	002 236	332		Z
	002 237	240		
	002 240	310		H
	002 241	240		
	002 242	320		P
	002 243	240		
	002 244	316		N
	002 245	240		
	002 246	303		C
	002 247	004		(Spaces)
	002 250	323		S
	002 251	247		'
	002 252	332		Z
	002 253	247		'
	002 254	310		H
	002 255	247		'
	002 256	320		P
	002 257	247		'
	002 260	316		N
	002 261	247		'
	002 262	303		C
	002 263	247		'

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	002 264	045		(Spaces)
	002 265	000		(Return)
	002 266			
	002 267			
	002 270			
	002 271			
	002 272			
	002 273	140		(Spaces)
	002 274	330		X
	002 275	240		
	002 276	311		I
	002 277	356		n
	002 300	344		d
	002 301	345		e
	002 302	370		x
	002 303	002		(Spaces)
	002 304	331		Y
	002 305	240		
	002 306	311		I
	002 307	356		n
	002 310	344		d
	002 311	345		e
	002 312	370		x
	002 313	003		(Spaces)
	002 314	311		I
	002 315	240		
	002 316	322		R
	002 317	345		e
	002 320	347		g
	002 321	003		(Spaces)
	002 322	322		R
	002 323	240		
	002 324	322		R
	002 325	345		e
	002 326	347		g
	002 327	041		(Spaces)
	002 330	000		(Return)
	002 331	141		(Spaces)
	002 332	323		S
	002 333	364		t
	002 334	341		a
	002 335	343		c
	002 336	353		k
	002 337	004		(Spaces)
	002 340	322		R
	002 341	345		e
	002 342	364		t
	002 343	365		u
	002 344	362		r
	002 345	356		n
	002 346	277		?

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	002 347	004		(Spaces)
	002 350	311		I
	002 351	356		n
	002 352	364		t
	002 353	345		e
	002 354	362		r
	002 355	362		r
	002 356	365		u
	002 357	360		p
	002 360	364		t
	002 361	043		(Spaces)
	002 362	000		(Return)
	002 363	377		(Home Erase)
	002 364	305		E
	002 365	356		n
	002 366	364		t
	002 367	345		e
	002 370	362		r
	002 371	240		
	002 372	320		P
	002 373	341		a
	002 374	347		g
	002 375	345		e
	002 376	240		
	002 377	000		(Return)
TV Dump	003 000	365		Push A & Flags
	003 001	305		Push B&C
	003 002	325		Push D&E
	003 003	345		Push H&L
	003 004	010		Ex A & Flags w A' & Flags'
	003 005	331		Ex B-L w B'-L'
	003 006	365		Push A' & Flags'
	003 007	305		Push B' &C'
	003 010	325		Push D' & E'
	003 011	345		Push H' & L'
	003 012	010		Ex A' & Flags' w A & Flags
	003 013	331		Ex B'-L' w B&L
	003 014	335		Push X
	003 015	345		
	003 016	375		Push Y
	003 017	345		
	003 020	355		Load A w I
	003 021	127		
	003 022	107		Load B w A
	003 023	355		Load A w R
	003 024	137		
	003 025	117		Load C w A
	003 026	345		Push L & H
	003 027	041		Clear L&H
	003 030	000		

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	003 031	000		
	003 032	071		ADD Stack Pointer to H&L
	003 033	006		Load B with 030
	003 034	030		
	003 035	043		Inc L&H
	003 036	020		Dec B, Jump Rel n Zero
	003 037	375		
	003 040	345		Push L&H (Push SP)
	003 041	116		Load C w Mem
	003 042	043		Inc L&H
	003 043	106		Load B w Mem
	003 044	305		Push B&C
	003 045	053		Dec L&H
	003 046	053		"
	003 047	053		"
	003 050	053		"
	003 051	345		Push L&H
	003 052	041		Load L&H
	003 053	121		(Title & Regs)
	003 054	002		
	003 055	315		Call (TV Ed)
	003 056	000		
	003 057	002		
	003 060	341		Pop L&H
	003 061	315		Call (Reg Print)
	003 062	240		
	003 063	003		
	003 064	345		Push L&H
	003 065	041		Load L&H
	003 066	175		(Regs')
	003 067	002		
	003 070	315		Call (TV Ed)
	003 071	000		
	003 072	002		
	003 073	341		Pop L&H
	003 074	315		Call (Reg Print)
	003 075	240		
	003 076	003		
	003 077	353		Ex D&E w H&L
	003 100	041		Load L&H
	003 101	224		(Flags)
	003 102	002		
	003 103	315		Call (TV Ed)
	003 104	000		
	003 105	002		
	003 106	006		Load B w 017
	003 107	017		
	003 110	023		Inc D&E
	003 111	020		Dec B, Jump Rel n Zero
	003 112	375		
	003 113	315		Call (Flag Print)

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	003 114	262		
	003 115	003		
	003 116	006		Load B w 010
	003 117	010		
	003 120	033		Dec D&E
	003 121	020		Dec B, Jump Rel n Zero
	003 122	375		
	003 123	315		Call (Flag Print)
	003 124	262		
	003 125	003		
	003 126	041		Load L&H
	003 127	273		(Indeces, I&R)
	003 130	002		
	003 131	315		Call (TV Editor)
	003 132	000		
	003 133	002		
	003 134	006		Load B w 006
	003 135	007		
	003 136	033		Dec D&E
	003 137	020		Dec B, Jump Rel n Zero
	003 140	375		
	003 141	353		Exchange D&E w H&L
	003 142	315		Call (Dump Char Short)
	003 143	341		
	003 144	003		
	003 145	315		Call (Dump Char Short)
	003 146	341		
	003 147	003		
	003 150	006		Load B with
	003 151	003		
	003 152	315		Call (Dump Char)
	003 153	334		
	003 154	003		
	003 155	315		Call (Dump Char Short)
	003 156	341		
	003 157	003		
	003 160	006		Load B with
	003 161	004		
	003 162	315		Call (Dump Char)
	003 163	334		
	003 164	003		
	003 165	006		Load B with
	003 166	005		
	003 167	315		Call (Dump Char)
	003 170	334		
	003 171	003		
	003 172	345		Push L&H
	003 173	041		Load L&H
	003 174	331		(Stack)
	003 175	002		
	003 176	315		Call (TV Ed)
	003 177	000		

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	003 200	002		
	003 201	341		Pop L&H
	003 202	315		Call (Dump Char Short)
	003 203	341		
	003 204	003		
	003 205	315		Call (Dump Char Short)
	003 206	341		
	003 207	003		
	003 210	006		Load B w 003
	003 211	003		
	003 212	315		Call (Dump Char)
	003 213	334		
	003 214	003		
	003 215	315		Call (Dump Char Short)
	003 216	341		
	003 217	003		
	003 220	006		Load B w 011
	003 221	011		
	003 222	315		Call (Space)
	003 223	370		
	003 224	000		
	003 225	020		Dec B, Jump Rel n Zero
	003 226	373		
	003 227	072		Load A w Mem, Direct
	003 230	246		
	003 231	001		
	003 232	315		Call (TV)
	003 233	372		
	003 234	000		
	003 235	303		Jump Uncondx
	003 236	346		(Storage)
	003 237	003		
	003 240	136		Load E w Mem
	003 241	315		Call (Char)
	003 242	106		
	003 243	002		
	003 244	053		Dec L&H
	003 245	006		Load B w 006
	003 246	006		
	003 247	315		Call (Space)
	003 250	370		
	003 251	000		
	003 252	053		Dec L&H
	003 253	315		Call (Char)
	003 254	105		
	003 255	002		

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	003 256	020		Dec B, Jump Rel n Zero
	003 257	367		
	003 260	053		Dec L&H
	003 261	311		Return
Flag Print	003 262	032		Load A w Mem, Using D&E
	003 263	315		Call (Flag Short)
	003 264	316		
	003 265	003		
	003 266	315		Call (Flag Short)
	003 267	316		
	003 270	003		
	003 271	315		Call (Flag Long)
	003 272	315		
	003 273	003		
	003 274	315		Call (Flag Long)
	003 275	315		
	003 276	003		
	003 277	315		Call (Flag Short)
	003 300	316		
	003 301	003		
	003 302	315		Call (Flag Short)
	003 303	316		
	003 304	003		
	003 305	006		Load B w 003
	003 306	003		
	003 307	315		Call (Space)
	003 310	370		
	003 311	000		
	003 312	020		Dec B, Jump Rel n Zero
	003 313	373		
	003 314	311		Return
Flag Long	003 315	007		Rotate Left
Flag Short	003 316	007		Rotate Left
	003 317	117		Load C w A
	003 320	346		And A w 001
	003 321	001		
	003 322	366		Or A w 260
	003 323	260		
	003 324	315		Call (TV)
	003 325	372		
	003 326	000		
	003 327	315		Call (Space)
	003 330	370		
	003 331	000		
	003 332	171		Load A w C
	003 333	311		Return

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
Dump Char	003 334	315		Call (Space)
	003 335	370		
	003 336	000		
	003 337	020		Dec B, Jump Rel n Zero
	003 340	373		
	003 341	315		Call (Char)
	003 342	105		
	003 343	002		
	003 344	053		Dec L&H
	003 345	311		Return
*The Following Code was generated by the Digital Group Assembler	ØØ3 346	Ø61 ØØØ ØØ2	Ø17Ø BEGIN	LD SP,ØØ2ØØØ
	ØØ3 351	Ø41 ØØØ ØØØ	Ø18Ø	LD HL,ØØØØØØ
	ØØ3 354	345	Ø19Ø	PUSH HL
	ØØ3 355	315 25Ø ØØ1	Ø2ØØ KEY	CALL ØØ125Ø
	ØØ3 36Ø	346 337	Ø21Ø	AND 337
	ØØ3 362	127	Ø22Ø	LD D,A
	ØØ3 363	376 2ØØ	Ø23Ø PTEST	CP 2ØØ *SPACE FOR NEW PAGE
	ØØ3 365	Ø4Ø ØØ3	Ø24Ø	JR NZ,RTEST
	ØØ3 367	321	Ø25Ø	POP DE *GET RID OF OLD HL
	ØØ3 37Ø	Ø3Ø 114	Ø26Ø	JR DCONV
	ØØ3 372	341	Ø27Ø RTEST	POP HL
	ØØ3 373	376 322	Ø28Ø	CP 322 *R RETURN TO OP SYS
	ØØ3 375	312 ØØØ ØØ5	Ø29Ø	JP Z,ØØ5ØØØ
	ØØ4 ØØØ	376 31Ø	Ø3ØØ HTEST	CP 31Ø *H
	ØØ4 ØØ2	Ø4Ø ØØ6	Ø31Ø	JR NZ,LTEST
	ØØ4 ØØ4	315 233 ØØ1	Ø32Ø	CALL HLOUT
	ØØ4 ØØ7	147	Ø33Ø	LD H,A
	ØØ4 Ø1Ø	Ø3Ø Ø74	Ø34Ø	JR DCONV
	ØØ4 Ø12	376 314	Ø35Ø LTEST	CP 314 *L
	ØØ4 Ø14	Ø4Ø ØØ6	Ø36Ø	JR NZ,STEST
	ØØ4 Ø16	315 233 ØØ1	Ø37Ø	CALL HLOUT
	ØØ4 Ø21	157	Ø38Ø	LD L,A
	ØØ4 Ø22	Ø3Ø Ø62	Ø39Ø	JR DCONV
	ØØ4 Ø24	376 214	Ø4ØØ STEST	CP 214 *RIGHT ARROW TO SPACE RIGHT
	ØØ4 Ø26	Ø4Ø ØØ3	Ø41Ø	JR NZ,BTEST
	ØØ4 Ø3Ø	Ø43	Ø42Ø	INC HL
	ØØ4 Ø31	Ø3Ø Ø53	Ø43Ø	JR DCONV
	ØØ4 Ø33	376 21Ø	Ø44Ø BTEST	CP 21Ø *LEFT ARROW TO BACKSPACE
	ØØ4 Ø35	Ø4Ø ØØ3	Ø45Ø	JR NZ,UTEST
	ØØ4 Ø37	Ø53	Ø46Ø	DEC HL
	ØØ4 Ø4Ø	Ø3Ø Ø44	Ø47Ø	JR DCONV
	ØØ4 Ø42	247	Ø48Ø UTEST	AND A *CLEAR CARRY
	ØØ4 Ø43	Ø21 Ø16 ØØØ	Ø49Ø	LD DE,ØØØØ16
	ØØ4 Ø46	376 213	Ø5ØØ	CP 213 *UP ARROW FOR LINE UP
	ØØ4 Ø5Ø	Ø4Ø ØØ4	Ø51Ø	JR NZ,DTEST
	ØØ4 Ø52	355 122	Ø52Ø	SBC HL,DE
	ØØ4 Ø54	Ø3Ø Ø3Ø	Ø53Ø	JR DCONV
	ØØ4 Ø56	376 212	Ø54Ø DTEST	CP 212 *DOWN ARROW FOR LINE DOWN
	ØØ4 Ø6Ø	Ø4Ø ØØ4	Ø55Ø	JR NZ,NTEST

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	004 062	355 132	0560	ADC HL,DE
	004 064	030 020	0570	JR DCONV
	004 066	366 040	0580 NTEST	OR 040 *RESTORE NUMBER
	004 070	365	0590	PUSH AF
	004 071	006 011	0600	LD B,011
	004 073	315 370 000	0610 SKIP	CALL 000370
	004 076	020 373	0620	DJNZ SKIP
	004 100	361	0630	POP AF
	004 101	315 251 004	0640	CALL ASCIIS
	004 104	167	0650	LD (HL),A
	004 105	043	0660	INC HL
	004 106	345	0670 DCONV	PUSH HL
	004 107	315 346 000	0680	CALL 000346 *ERASE TV
	004 112	321	0690	POP DE *GET HL INTO DE
	004 113	325	0700	PUSH DE *BACK TO NORMAL
	004 114	142	0710	ID H,D *POINTER ON DISPLAYED PAGE
	004 115	173	0720	LD A,E
	004 116	376 200	0730 PAGE1	CP 200
	004 120	060 014	0740	JR NC,PAGE3
	004 122	056 000	0750	LD L,000
	004 124	030 012	0760	JR PSTART
	004 126	376 264	0770	CP 264
	004 130	060 004	0780	JR NC,PAGE3
	004 132	056 132	0790	LD L,132
	004 134	030 002	0800	JR PSTART
	004 136	056 200	0810 PAGE3	LD L,200
	004 140	134	0820 PSTART	LD E,H
	004 141	315 106 002	0830	CALL 002106 *CHARACTER
	004 144	135	0840	LD E,L
	004 145	315 106 002	0850	CALL 002106
	004 150	315 370 000	0860	CALL 000370 *SPACE
	004 153	315 370 000	0870	CALL 000370 *SPACE
	004 156	006 016	0880	LD B,016
	004 160	321	0890 BYTE	POP DE *PUT STACK HL IN DE
	004 161	345	0900	PUSH HL
	004 162	325	0910	PUSH DE
	004 163	355 122	0920	SBC HL,DE *SEE IF POINTER HERE?
	004 165	050 005	0930	JR Z,POINTR
	004 167	315 370 000	0940	CALL 000370
	004 172	030 005	0950	JR CONTIN
	004 174	076 232	0960 POINTR	LD A,232 *ARROW
	004 176	315 372 000	0970	CALL 000372
	004 201	321	0980 CONTIN	POP DE
	004 202	341	0990	POP HL
	004 203	325	1000	PUSH DE
	004 204	136	1010	LD E,(HL)
	004 205	315 106 002	1020	CALL 002106 *PRINT BYTE
	004 210	043	1030	INC HL
	004 211	175	1040	LD A,L
	004 212	376 200	1050	CP 200
	004 214	312 230 004	1060	JP Z,ADD
	004 217	000	1070	NOP

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	ØØ4 22Ø	ØØØ	1Ø8Ø	NOP
	ØØ4 221	ØØØ	1Ø9Ø	NOP
	ØØ4 222	ØØØ	11ØØ	NOP
	ØØ4 223	ØØØ	111Ø	NOP
	ØØ4 224	376 ØØØ	112Ø	CP ØØØ
	ØØ4 226	Ø4Ø Ø12	113Ø	JR NZ,NBYTE
	ØØ4 23Ø	ØØ6 21Ø	114Ø ADD	LD B,21Ø
	ØØ4 232	315 37Ø ØØØ	115Ø SKIP7	CALL ØØØ37Ø
	ØØ4 235	Ø2Ø 373	116Ø	DJNZ SKIP7
	ØØ4 237	3Ø3 355 ØØ3	117Ø	JP KEY
	ØØ4 242	Ø2Ø 314	118Ø NBYTE	DJNZ BYTE
	ØØ4 244	Ø3Ø 272	119Ø	JR PSTART
	ØØ4 246	315 25Ø ØØ1	12ØØ ASCII	CALL ØØ125Ø *KEYBOARD # ENTRY
	ØØ4 251	1Ø7	121Ø ASCIIS	LD B,A
	ØØ4 252	Ø72 247 ØØ1	122Ø	LD A,(ØØ1247)
	ØØ4 255	376 31Ø	123Ø HEXCK	CP 'H'
	ØØ4 257	17Ø	124Ø	LD A,B
	ØØ4 26Ø	Ø5Ø Ø44	125Ø	JR Z,HEX
	ØØ4 262	315 372 ØØØ	126Ø OCTAL	CALL ØØØ372
	ØØ4 265	17Ø	127Ø	LD A,B
	ØØ4 266	Ø17	128Ø	RRCA
	ØØ4 267	Ø17	129Ø	RRCA
	ØØ4 27Ø	346 3ØØ	13ØØ	AND 3ØØ
	ØØ4 272	117	131Ø	LD C,A
	ØØ4 273	315 25Ø ØØ1	132Ø	CALL ØØ125Ø
	ØØ4 276	1Ø7	133Ø	LD B,A
	ØØ4 277	315 372 ØØØ	134Ø	CALL ØØØ372
	ØØ4 3Ø2	17Ø	135Ø	LD A,B
	ØØ4 3Ø3	ØØ7	136Ø	RLCA
	ØØ4 3Ø4	ØØ7	137Ø	RLCA
	ØØ4 3Ø5	ØØ7	138Ø	RLCA
	ØØ4 3Ø6	346 Ø7Ø	139Ø	AND Ø7Ø
	ØØ4 31Ø	2Ø1	14ØØ	ADD C
	ØØ4 311	117	141Ø	LD C,A
	ØØ4 312	315 25Ø ØØ1	142Ø	CALL ØØ125Ø
	ØØ4 315	1Ø7	143Ø	LD B,A
	ØØ4 316	315 372 ØØØ	144Ø	CALL ØØØ372
	ØØ4 321	17Ø	145Ø	LD A,B
	ØØ4 322	346 ØØ7	146Ø	AND ØØ7
	ØØ4 324	2Ø1	147Ø	ADD C
	ØØ4 325	311	148Ø	RET
	ØØ4 326	315 37Ø ØØØ	149Ø HEX	CALL ØØØ37Ø
	ØØ4 331	17Ø	15ØØ	LD A,B
	ØØ4 332	315 352 ØØ4	151Ø	CALL HEXERS
	ØØ4 335	ØØ7	152Ø	RLCA
	ØØ4 336	ØØ7	153Ø	RLCA
	ØØ4 337	ØØ7	154Ø	RLCA
	ØØ4 34Ø	ØØ7	155Ø	RLCA
	ØØ4 341	1Ø7	156Ø	LD B,A
	ØØ4 342	315 347 ØØ4	157Ø	CALL HEXER
	ØØ4 345	2ØØ	158Ø	ADD B

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	ØØ4 346	311	159Ø	RET
	ØØ4 347	315 25Ø ØØ1	16ØØ HEXER	CALL ØØ125Ø
	ØØ4 352	376 34Ø	161Ø HEXERS	CP 34Ø
	ØØ4 354	Ø7Ø ØØ2	162Ø	JR C,UCASE
	ØØ4 356	326 Ø4Ø	163Ø	SUB Ø4Ø
	ØØ4 36Ø	365	164Ø UCASE	PUSH AF
	ØØ4 361	315 372 ØØØ	165Ø	CALL ØØØ372
	ØØ4 364	361	166Ø	POP AF
	ØØ4 365	376 272	167Ø	CP 272
	ØØ4 367	Ø7Ø ØØ2	168Ø	JR C,NUMBER
	ØØ4 371	326 ØØ7	169Ø	SUB ØØ7
	ØØ4 373	326 26Ø	17ØØ NUMBER	SUB 26Ø
	ØØ4 375	311	171Ø	RET
	ØØ4 376	ØØØ	172Ø	NOP
	ØØ4 377	ØØØ	173Ø	NOP
OP Monitor	005 000	061		Load Stack Pointer
	005 001	000		
	005 002	002		
	005 003	355		Set Interrupt Mode Ø
	005 004	106		(8080 identical)
	005 005	076		Load A w "Ø"
	005 006	260		
	005 007	062		Load Mem w A, Direct
	005 010	246		
	005 011	001		
	005 012	373		Enable Interrupt
	005 013	041		Load L&H
	005 014	124		
	005 015	005		
	005 016	315		Call (TV Editor)
	005 017	000		
	005 020	002		
(1)	005 021	315		Call (Keyboard)
	005 022	250		
	005 023	001		
	005 024	376		Compare A w >9
	005 025	272		
	005 026	060		Jump Rel if not Less
	005 027	371		(1)
	005 030	376		Compare A w <Ø
	005 031	260		
	005 032	070		Jump Rel if Less
	005 033	365		(1)
	005 034	007		Shift Left
	005 035	346		And A w 136
	005 036	136		
	005 037	062		Load Mem w A, Direct
	005 040	067		
	005 041	005		
	005 042	376		Compare A w 106

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	005 043	106		
	005 044	070		Jump Rel if less
	005 045	020		(2)
	005 046	376		Compare A w 112
	005 047	112		
	005 050	060		Jump Rel if not less
	005 051	014		(2)
	005 052	376		Compare A w 110
	005 053	110		
	005 054	060		Jump Rel if not less
	005 055	003		(3)
	005 056	257		Clear A
	005 057	030		Jump Rel
	005 060	002		(4)
(3)	005 061	076		Load A w "H"
	005 062	310		
(4)	005 063	062		Load M w A, Direct
	005 064	247		
	005 065	001		
(2)	005 066	052		Load H&L, Direct
	005 067	*		
	005 070	005		
	005 071	315		Call (Home Erase)
	005 072	346		
	005 073	000		
	005 074	351		Load Prog Ctr w H&L
	005 075			
	005 076			
	005 077			
	005 100			Ø (User set)
	005 101			
	005 102	167		1 Read
	005 103	000		
	005 104	040		2 Write
	005 105	001		
	005 106	000		3 Octal Program
	005 107	003		
	005 110	000		4 Hex Program
	005 111	003		
	005 112			5 (User Set)
	005 113			
	005 114			6 (User Set)
	005 115			
	005 116			7 (User Set)
	005 117			
	005 120			8 (User Set)
	005 121			
	005 122			9 (User Set)
	005 123			
	005 124	377		(Home Erase)
	005 125	032		(Spaces)

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	005 126	332		Z
	005 127	255		-
	005 130	270		8
	005 131	260		O
	005 132	240		
	005 133	317		O
	005 134	320		P
	005 135	240		
	005 136	323		S
	005 137	331		Y
	005 140	323		S
	005 141	033		(Spaces)
	005 142	317		O
	005 143	360		p
	005 144	364		t
	005 145	351		i
	005 146	357		o
	005 147	356		n
	005 150	363		s
	005 151	272		:
	005 152	170		(Spaces)
	005 153	261		1
	005 154	240		
	005 155	322		R
	005 156	305		E
	005 157	301		A
	005 160	304		D
	005 161	072		(Spaces)
	005 162	262		2
	005 163	240		
	005 164	327		W
	005 165	322		R
	005 166	311		I
	005 167	324		T
	005 170	305		E
	005 171	071		(Spaces)
	005 172	263		3
	005 173	240		
	005 174	317		O
	005 175	343		c
	005 176	364		t
	005 177	341		a
	005 200	354		l
	005 201	240		
	005 202	320		P
	005 203	362		r
	005 204	357		o
	005 205	347		g
	005 206	362		r
	005 207	341		a
	005 210	355		m

PROGRAM: Z-80 OPERATING SYSTEM

LABEL	OCTAL ADDRESS	OCTAL CODE	MNEMONICS	COMMENTS
	005 211	061		(Spaces)
	005 212	264		4
	005 213	240		
	005 214	310		H
	005 215	345		e
	005 216	370		x
	005 217	240		
	005 220	320		p
	005 221	362		r
	005 222	357		o
	005 223	347		g
	005 224	362		r
	005 225	341		a
	005 226	355		m
	005 227	063		(Spaces)
	005 230	000		(Return)