

LOADING PROGRAMS

Introduction

When a computer is first manufactured, it "knows" nothing. It does not even know how to read in program tapes. The reading in of program tapes, called "loading," is accomplished using a fairly complex program called the Self-Checking Binary Loader. This program occupies locations 7632 - 7777₈, and once loaded should remain in memory permanently. All 1080 computers contain this program when shipped from the factory. The only conditions under which the Binary Loader must be reloaded are (a) if an experimental program runs wild or (b) if a power failure occurs while the 1080 is running.

Loading Programs Using the Binary Loader

Since the Binary Loader is self-checking, one can always start the computer at location 7777 and assume that if tape reads in, the loader is intact. If the computer halts when started at 7777, this indicates that the loader has been destroyed and it must be reloaded using Nico-Loadeon, as described in the next section.

To load a program tape using the Binary Loader:

- (a) Depress Wired Program STOP and Stored Program STOP to make sure the computer is not running.
- (b) Place the program tape, printed side up, in the tape reader. If you have a high speed reader, place the tape in the right-hand side and feed it through to the left-hand side. If you have only a low speed reader, set the reader switch to Free, place the tape in the reader, and turn the switch to Start.
- (c) Be sure that the power to the reader is turned on. For the high speed reader, this is an on-off switch on the front. For the low speed reader, turn the Teletype power switch to the Line position.
- (d) Set the switch register to 7777₈ (00 000 000 111 111 111 111). In this position, the right-hand twelve switches are up and the left eight switches are down.
- (e) Depress LOAD PC.
- (f) Press Execute
- (g) Depress CONTINUE
- (h) Press Execute.

The program should start reading in the binary tape. The Self-Checking Binary Loader automatically selects the correct tape reader. If the system contains a high speed reader, and the reader has tape in it, the program will be read from the high speed reader. If there is no high speed reader, or it contains no tape, the low speed reader will be used. If the program does not start, and the STOP light comes on, the Binary Loader has been destroyed and must be reloaded.

The Binary Loader program will halt under only two other conditions: (a) a checksum error, or (b) a rubout in the trailer of the tape. If the tape suddenly stops during read-in and the Teletype bell rings, a checksum error has been found. This indicates a tape reading error and means that the tape must be restarted at the beginning. Checksum errors are usually caused by torn or bent tape, tape loaded backwards, or occasionally, Teletype failure. Be sure to investigate the first two causes carefully before blaming the third. It is a good idea to duplicate all valuable tapes so that there is always a back-up copy available.

The only legal halt for the binary loader is upon finding a rubout (all 8 holes punched) in the trailer section of the tape. If the tape halts on a rubout while reading in the leader you have probably placed it in the reader backwards. Be sure to check the directional arrows printed on the tape before starting the Binary Loader. If the Binary Loader halts on a rubout, it may be restarted to read additional tapes by depressing Continue and pressing Execute.

Note that the Binary Loader is always started at 7777_8 . The starting address printed on the tape label refers to the address at which the program is started once loaded. It does not refer to the Binary Loader.

Reloading the Binary Loader Using Nico-Loadeon

One could, of course, toggle in the entire Binary Loader at the switch register. However, this program is quite lengthy, occupying over 100 core locations, and this would be extremely tedious. A more efficient method is to write a shorter program, or "bootstrap" loader which then reads in the longer loading program. Nico-Loadeon utilizes this method twice. One first toggles in fourteen instructions and then reads in a two part tape through the low speed reader. The first part is read in using the toggled instructions and the second part using the program contained in the first section. When the second section is read in completely, the Self-Checking Binary Loader is resident and is used to read in all other tapes.

The fourteen instructions comprising Nico-Loadeon have been carefully designed to be entered with a minimum of switch register manipulation. Thus, in several cases, a number of switches stay the same between instructions, and in one case, an instruction is entered three times in succession.

The following instructions constitute the switch register portion of Nico-Loadeon. The Assembler mnemonic equivalents are given on the right, but are not needed to enter and use the program successfully.

	<u>Address</u>	<u>Contents</u>	<u>Assembler Equivalent</u>	
	7736	7744	READ, R2	-7751
	7737	5007	LASH 7	
S. A. =	7740	4453	RDTTY	4463
	7741	6454	T1, TTYRF	6464
	7742	1741	JMP T1	
	7743	1001736	JMP @ READ	
	7744	0171736	R2, ZERA	
	7745	2705751	MMOM R4	
	7746	2001736	JMS READ	
	7747	2001736	JMS READ	
	7750	2001736	R3, JMS READ	
	7751	2407777	R4, ACCMZ 7777	2407752
	7752	1744	JMP R2	0
	7753	1750	JMP R3	5007

To toggle in Nico-Loadeon, set the switch register to 7736 (00 000 000 111 111 011 110), depress LOAD PC and press Execute. The value 7736 will appear in the PC and the AC.

Then depress Deposit and Step, toggle in the instructions one by one, and press Execute to deposit each of them. Note that it is only necessary to load the first address into the PC, since Step automatically advances the location counter (PC) to the next address each time Execute is pressed. Thus, the contents of locations 7746-7750 can be entered by setting the switch register to 2001736 and pressing Execute three times in succession.

When you have toggled in all 14 instructions, go back and check to see that they have been entered correctly. This is accomplished by setting the switch register to 7736, depressing Load PC and pressing Execute. Then the locations are examined by depressing Examine while Step is depressed. The contents of a new memory location are displayed in the AC each time Execute is pressed. Since the Step button automatically increments the PC each time, the PC will always show an address one ahead of that being displayed.

When you are sure that the instructions have been entered correctly, place the Nico-Loadeon tape, printed side up, in the Teletype tape reader. The leader of this tape is entirely blank: it contains no punches along the right-hand side. Be sure that there is an inch or two of leader remaining before the first punched holes in the tape. Turn the reader to START and then start the computer at location 7740. This is accomplished by setting the switch register to 7740 (00 000 000 111 111 100 000), depressing Load PC, pressing Execute, depressing Continue and pressing Execute. (Be sure that you do not inadvertently press Start instead.)

The program should start and read in the tape. If the tape motion halts at any time, it indicates a program error. Go back, be sure that Nico-Loadeon is properly toggled in and start again.

Nico-Loadeon is self-modifying. This means that it will change as the tape reads in. When the tape has read in about one third of the way, the program will automatically change so that the section just read in is now in control and it reads in the rest of the tape.

When the tape has read in beyond all data holes, and the program is reading only trailer tape (containing holes along the right side only) the program may be stopped by turning off the tape reader and pressing Stop on the computer console. The Self-Checking Binary Loader is now loaded and can be started at 7777 to read in tapes, as described on page 1.

Binary Tape Format

Both the Intermediate and the Self-Checking Binary Loader utilize the same format of input tape. The only difference is that the longer loader uses the checksum information at the end of each section to check for read-in errors. The format is described below.

- (1) Leader - A row of column 7 (200₈) punches is used as leader and trailer. It must come before the first load information.
- (2) Data Format - Each 20-bit computer word is broken into three lines on paper tape, utilizing only columns 0-6. Column 7 is used to indicate a checksum and trailer. The word is broken up as follows:

Line 1	bits 19 - 14 (in tape columns 5-0)
Line 2	bits 13 - 7
Line 3	bits 6 - 0

The loader assembles each word from the three lines and adds it into a running sum, or "checksum."

- (3) Load Address - The first 20-bit word following the leader, or following each checksum, is the starting address for the data that follows. The load address is included in the checksum.
- (4) Data Words - Each 20-bit word following the load address is deposited in memory in sequential locations starting at the load address, and added into the checksum.
- (5) Checksum - At the end of each block of sequential data, the checksum is punched. It is the lowest order 20 bits of the running sum kept of that data block. It differs from actual load data only in that it has column 7 punched as well as columns 0-6. Following the checksum may be either a new load address or trailer code.

- (6) Trailer Code - This is identical to leader tape, except that it may have a Rubout punched in it. A rubout punched in pure trailer tape is a signal for the Binary Loader to halt.

Listing of the Loader Programs

Nico-Loadeon is listed on page 3. It operates by clearing the Teletype buffer and then skipping further reads at 7751 until a non-zero character is found. This is deposited at 7776. It then decrements the deposit address and deposits each assembled word in the next lower address. The last word is deposited in 7752, which causes a jump to the intermediate loader.

The intermediate loader, sometimes called the Short Binary Loader, is listed and explained below. The Self-Checking Binary Loader is listed following that.

/INTERMEDIATE BINARY LOADER
/CONTAINED IN NICO-LOADEON; NIC-80/S-7115B

*7752

7752	0	READ, 0	/TAPE READ SUBROUTINE
7753	5007	LASH 7	/SHIFT PREVIOUS AC CONTENTS ✓
7754	6454	BACK, TTYRF	/WAIT FOR TELETYPE FLAG
7755	1754	JMP BACK ✓	
7756	4453	4453	/“OR” TTY WITH AC
7757	1001752	JMP 0 READ	/EXIT READ SUBROUTINE
7760	0	NEXT, 0	/SUBROUTINE TO ASSEMBLE 20-BIT WORD
7761	170000	ZERA	/CLEAR AC
7762	2001752	JMS READ	/READ ONE TTY CHARACTER
7763	2200	ANDZ (200	/IS THIS LEADER, TRAILER OR CHECKSUM?
7764	1770	JMP START	/YES, GET NEW LOAD ADDRESS
7765	2001752	JMS READ	/NO, GET REMAINING BYTES
7766	2001752	JMS READ	
7767	1001760	JMP 0 NEXT	/AND EXIT
7770	2001760	START, JMS NEXT	/GET NEW LOAD ADDRESS
7771	2405776	ACCM POINT	/STORE IN POINTER LOCATION
7772	2001760	CONT, JMS NEXT	/GET EACH DATA WORD
7773	3405776	ACCM 0 POINT	/AND STORE IT
7774	2125776	MPOM POINT	/INCREMENT DATA WORD POINTER
7775	1772	JMP CONT	/AND CONTINUE
7776	0	POINT, 0	/POINTER TO DATA LOCATION

/SELF CHECKING BINARY LOADER WITH AUTO-READER SELECTION
 /NIC-80/S-7115B-L

*7632

7632 0 READER, 0 /POINTER TO READER SUBROUTINE
 7633 3052562 CM, 3052562 /SUM OF ADDRESSES 7634 - 7751

/INITIALIZE SELF CHECKER

7634 110115 START, MEMA (115 /INITIALIZE COUNTER
 7635 2225721 ANGM CHEK /AND STORE NEGATIVE OF 115
 7636 2165731 ZERM SUM /ZERO SUM
 7637 2165734 ZERM HS /AND SUBROUTINES
 7640 2165744 ZERM LS
 7641 2111742 MEMA CA /SET POINTER TO START OF ADDRESSES
 7642 2545733 AMOM POINT

/ADD TOGETHER CONTENTS OF LOCATIONS 7634-7751

7643 2135733 CL, MPOAM POINT
 7644 3111733 MEMA @ POINT /GET CONTENTS OF EACH ADDRESS
 7645 2515731 A+MAM SUM /AND ADD INTO SUM FOR SELF CHECKING
 7646 2127721 MPOMZ CHEK /LAST ADDRESS?
 7647 1643 JMP CL /NO, GET MORE
 7650 2473633 A-MAZ CM /COMPARE WITH CORRECT SUM
 7651 5220 HALT, STOP /HALT IF THEY DO NOT AGREE

/NOW SELECT THE PROPER READER

7652 166464 166464 /SKIP ON HSR FLAG & CLEAR AC
 7653 110010 MEMA (10 /NO. OF ADDRESSES BETWEEN READ ROUTINES
 7654 2511743 A+MA READ /MAKE HS INTO LS IF NO HSR
 7655 2405632 ACCM READER /STORE CORRECT READ POINTER
 7656 44453 RDTTY /CLEAR TTY FLAG AND START LOADING

 7657 170000 LEAD, ZERA
 7660 3001632 JMS @ READER /GET FIRST CHARACTER
 7661 2200 ANDZ (200 /MUST HAVE LEADER TO LOAD
 7662 162000 ZERZ
 7663 1657 JMP LEAD /WAIT IN THIS LOOP UNTIL LEADER IS SENSED

7664 2175731 LOAD, ZERMA SUM /CLEAR CHECKSUM
 7665 3001632 JMS @ READER
 7666 462377 A-MZ (377 /RUBOUT?
 7667 162000 ZERZ /SKIP
 7670 1651 JMP HALT /YES, HALT
 7671 2200 ANDZ (200 /LEADER?
 7672 1664 JMP LOAD /YES, TRY AGAIN

7673 3001632 ADDRES, JMS @ READER
 7674 3001632 JMS @ READER
 7675 2405733 ACCM POINT /FIRST WORD IS LOAD ADDRESS
 7676 2505731 NEXT, A+MM SUM /ADD INTO CHECKSUM
 7677 170000 ZERA

7700 3001632 JMS @ READER /GET DATA WORDS
 7701 2200 ANDZ (200 /LEADER-TRAILER-CHECKSUM?
 7702 1710 JMP CHECK /YES
 7703 3001632 JMS @ READER /NO, ASSEMBLE REMAINING BYTES
 7704 3001632 JMS @ READER
 7705 3405733 ACCM @ POINT /AND STORE IN POINTER LOCATION
 7706 2125733 MPOM POINT /INCREMENT POINTER
 7707 1676 JMP NEXT /AND CONTINUE

7710 2001721 CHECK, JMS CHEK /READ IN CHECKSUM
 7711 2001721 JMS CHEK /MASKING OUT BIT 7
 7712 2467731 A-MZM SUM /DOES IT = CHECKSUM?
 7713 1715 JMP ERROR /NO, RING BELL AND HALT
 7714 1664 JMP LOAD /YES, LOOK FOR MORE SECTIONS

7715 110207 ERROR, MEMA (207 /BELL
 7716 4443 PRTTY /RING IT
 7717 2111731 MEMA SUM /PUT ERROR IN AC

7720 1651 JMP HALT /AND HALT
 7721 0 CHEK, 0 /SUBROUTINE TO READ IN CHECKSUM
 7722 5210 CLL
 7723 5150 EXCT AC0
 7724 5204 STL /SET LINK IF BIT 0=1
 7725 3001632 JMS @ READER /READ IN ONE BYTE
 7726 5101 SKIP L
 7727 2011732 ANDA M200 /MASK OUT BIT 7 IF NON-DATA
 7730 1001721 JMP @ CHEK /AND EXIT

7731 0 SUM, 0 /CHECKSUM LOCATION
 7732 3777577 M200, 3777577 /MASK FOR CHECKSUM WORDS
 7733 0 POINT, 0 /DATA POINTER

7734 0 HS, 0 /HIGH SPEED READER SUBROUTINE
 7735 5007 LASH 7 /SHIFT CURRENT AC
 7736 6464 BACKK, HSRF /WAIT FOR FLAG
 7737 1736 JMP BACKK
 7740 4463 4463 /"OR" HSR WITH AC
 7741 1001734 JMP @ HS /AND EXIT
 7742 7634 CA, START /POINTER FOR INITIALIZING SELF-CHECKER
 7743 7734 READ, HS /POINTER TO HIGH SPEED READER ROUTINE

7744 0 LS, 0 /LOW SPEED READER ROUTINE
 7745 5007 LASH 7
 7746 6454 L1, TTYRF /WAIT FOR TTY FLAG
 7747 1746 JMP L1
 7750 4453 4453 /"OR" TTY WITH AC
 7751 1001744 JMP @ LS

*7777
 7777 1634 JMP START /POINTER TO START OF BINARY LOADER

sets the desired number into the switch register and depresses DEPOSIT followed by Execute. As before, if STEP is depressed, the PC will be incremented automatically allowing the next sequential memory location to be modified by simply setting the next number into the switch register and pressing Execute again.

B. Loading Programs Using the Binary Loader

When a computer is first manufactured, it "knows" nothing. It does not even know how to read in program tapes. The reading in of program tapes, called "loading," is accomplished using a fairly complex program called the Self-Checking Binary Loader. This program occupies locations 7632 - 7777₈, and once loaded should remain in memory permanently. All 1080 computers contain this program when shipped from the factory. The only conditions under which the Binary Loader must be reloaded are (a) if an experimental program runs wild or (b) if a power failure occurs while the 1080 is running.

Since the Binary Loader is self-checking, one can always start the computer at location 7777 and assume that if tape reads in, the loader is intact. If the computer halts when started at 7777, this indicates that the loader has been destroyed and must be reloaded using Nico-Loadeon, as described in the next section.

To load a program tape using the Binary Loader:

- (1) Depress Wired Program STOP and Stored Program STOP to make sure the computer is not running.
- (2) Place the program tape, printed side up, in the tape reader. If you have a high speed reader, place the tape in the right-hand side and feed it through to the left-hand side. If you have only a low speed reader, set the reader switch to Free, place the tape in the reader, and turn the switch to Start.
- (3) Be sure that the power to the reader is turned on. For the high speed reader, this is an on-off switch on the front. For the low speed reader, turn the Teletype power switch to the Line position.
- (4) Set the switch register to 7777₈ (00 000 000 111 111 111 111). In this position, the right-hand twelve switches are up and the left eight switches are down.
- (5) Depress LOAD PC.
- (6) Press Execute.
- (7) Depress CONTINUE.
- (8) Press Execute.

The program should start reading in the binary tape. The Self-Checking Binary Loader automatically selects the correct tape reader. If the system contains a high speed reader, and the reader has tape in it, the program will be read from the high speed reader. If there is no high speed reader, or it contains no tape, the low speed reader will be used. If the program does not start, and the STOP light comes on, the Binary Loader has been destroyed and must be reloaded.

The Binary Loader program will halt under only two other conditions: (a) a checksum error, or (b) a rubout in the trailer of the tape. If the tape suddenly stops during read-in and the Teletype bell rings, a checksum error has been found. This indicates a tape reading error and means that the tape must be restarted at the beginning. Checksum errors are usually caused by torn or bent tape, tape loaded backwards, or occasionally, Teletype failure. Be sure to investigate the first two causes carefully before blaming the third. It is a good idea to duplicate all valuable tapes so that there is always a back-up copy available.

The only legal halt for the binary loader is upon finding a rubout (all 8 holes punched) in the trailer section of the tape. If the tape halts on a rubout while reading in the leader you have probably placed it in the reader backwards. Be sure to check the directional arrows printed on the tape before starting the Binary Loader. If the Binary Loader halts on a rubout, it may be restarted to read additional tapes by depressing Continue and pressing Execute.

Note that the Binary Loader is always started at 7777₈. The starting address printed on the tape label refers to the address at which the program is started once loaded. It does not refer to the Binary Loader.

C. Reloading the Binary Loader Using Nico-Loadeon

One could, of course, toggle in the entire Binary Loader at the switch register. However, this program is quite lengthy, occupying over 100 core locations, and this would be extremely tedious. A more efficient method is to write a shorter program, or "bootstrap" loader which then reads in the longer loading program. Nico-Loadeon utilizes this method twice. One first toggles in fourteen instructions and then reads in a two part tape through the low speed reader. The first part is read in using the toggled instructions and the second part using the program contained in the first section. When the second section is read in completely, the Self-Checking Binary Loader is resident and is used to read in all other tapes.

The fourteen instructions comprising Nico-Loadeon have been carefully designed to be entered with a minimum of switch register manipulation. Thus, in several cases a number of switches stay the same between instructions, and in one case, an instruction is entered three times in succession.

The following instructions constitute the switch register portion of Nico-Loadeon. The Assembler mnemonic equivalents are given on the right, but are not needed to enter and use the program successfully.

	<u>Address</u>	<u>Contents</u>	<u>Assembler Equivalent</u>
	7736 *	7744	READ, R2
	7737 *	5007	LASH 7
S. A. =	7740	4453	RDTTY 4453 for High speed reader
	7741	6454	T1, TTYRF 6454
	7742	1741	JMP T1
	7743	1001736	JMP @ READ
	7744	0171736	R2, ZERA
	7745	2705751	MMOM R4
	7746	2001736	JMS READ
	7747	2001736	JMS READ
	7750	2001736	R3, JMS READ
	7751	2407777	R4, ACCMZ 7777
	7752	1744	JMP R2
	7753	1750	JMP R3

To toggle in Nico-Loadeon, set the switch register to 7736 (00 000 000 111 111 011 110), depress LOAD PC and press Execute. The value 7736 will appear in the PC and the AC.

Then depress Deposit and Step, toggle in the instructions one by one, and press Execute to deposit each of them. Note that it is only necessary to load the first address into the PC, since STEP automatically advances the location counter (PC) to the next address each time Execute is pressed. Thus, the contents of locations 7746-7750 can be entered by setting the switch register to 2001736 and pressing Execute three times in succession.

When you have toggled in all 14 instructions, go back and check to see that they have been entered correctly. This is accomplished by setting the switch register to 7736, depressing LOAD PC and pressing Execute. Then the locations are examined by depressing Examine while STEP is depressed. The contents of a new memory location are displayed in the AC each time Execute is pressed. Since the Step button automatically increments the PC each time, the PC will always show an address one ahead of that being displayed.

When you are sure that the instructions have been entered correctly, place the Nico-Loadeon tape, printed side up, in the Teletype tape reader. The leader of this tape is entirely blank: it contains no punches along the right-hand side. Be sure that there is an inch or two of leader remaining before the first punched holes in the tape. Turn the reader to START and then start the computer at location 7740. This is accomplished by setting the switch register to 7740 (00 000 000 111 111 100 000), depressing Load PC, pressing Execute, depressing Continue and pressing Execute. (Be sure that you do not inadvertently press Start instead.)

The program should start and read in the tape. If the tape motion halts at any time, it indicates a program error. Go back, be sure that Nico-Loadeon is properly toggled in and start again.

Nico-Loadeon is self-modifying. This means that it will change as the tape reads in. If you have to restart the program, you can expect that locations 7736, 7751, 7752, and 7753 will have changed. When the tape has read in about one third of the way, the program will automatically change so that the section just read in is now in control and it reads in the rest of the tape.

When the tape has read in beyond all data holes, and the program is reading only trailer tape (containing holes along the right side only) the program may be stopped by turning off the tape reader and pressing STOP on the computer console. The Self-Checking Binary Loader is now loaded and can be started at 7777 to read in tapes, as described on page 49.

D. Binary Tape Format

Both the Intermediate and the Self-Checking Binary Loader utilize the same format of input tape. The only difference is that the longer loader uses the checksum information at the end of each section to check for read-in errors. The format is described below.

- (1) Leader - A row of column 7 (200g) punches is used as leader and trailer. It must come before the first load information.
- (2) Data Format - Each 20-bit computer word is broken into three lines on paper tape, utilizing only columns 0-6. Column 7 is used to indicate a checksum and trailer. The word is broken up as follows:

Line 1	bits 19 - 14 (in tape columns 5 - 0)
Line 2	bits 13 - 7
Line 3	bits 6 - 0

The loader assembles each word from the three lines and adds it into a running sum, or "checksum."

- (3) Load Address - The first 20-bit word following the leader, or following each checksum, is the starting address for the data that follows. The load address is included in the checksum.
- (4) Data Words - Each 20-bit word following the load address is deposited in memory in sequential locations starting at the load address and added into the checksum.