NATIONAL BUREAU OF STANDARDS REPORT

THE NBS CORD TIME SHARING SYSTEM

by

Thomas N. Pyke, Jr.

NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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CORD is an operating system for a Computer with On-Line Remote Devices. The system consists of an executive program designed to enable the dual-processor MOBIDIC computer facility with multiple remote terminals to operate in a time-shared mode. At each of a number of remote terminals, including teletypes and display subsystems, programs and data can be entered into the system, program execution initiated, and results returned to the terminals. A data base is available to all users through the system.

This reference manual contains all the necessary information for use of the CORD system from a teletype terminal. Although designed to be accompanied by a short course on the system, most of the manual is self-explanatory.

Section I, CORD Operating Procedures, contains the Login Procedure, the method for Entering System Commands, and a description of the available System Commands. Section I concludes with an outline of user program execution.

Section II is a description of programs that can be run in the time-shared mode. The User Program Machine Instruction Format is followed by the User Program Operation Codes. Next is a description of the CORD Command Vectors, the means by which system commands are called from user programs. A summary of Error Returns and Error Numbers accompanied by a listing of internal character representations concludes the manual.

The contents of this manual describe the system in operational status at NBS as of March 1966. Part of the basic system, including activation of the disc file, is yet to be fully operational. Supplements to this manual will provide up-to-date information concerning these and other extensions to be made to the system.

I. CORD OPERATING PROCEDURES

The following procedures are for access to the system through a local or remote teletype. For either a model 33 or 35 usage is the same. These procedures assume that the user has knowledge of the various special keys on the teletype and that either the teletype is local or that an appropriate remote connection has been made.

For convenience in explanation, the following terminology will be used:

1. All computer output will be underlined.
2. The symbol "↵" will represent the carriage return.
3. The symbol "ctrl-n" will represent any key labeled n (i.e. n = A or B or ...) depressed while the control key is depressed.

a. Login Procedure

Type: CORD↵

System replies: USER

Type: NNN↵ ("NNN" ≡ user's identification)

NOTE: All users of CORD must be assigned an official identification.

System replies: CORD READY
>

NOTE: The symbol ">" typed by the computer always means the system is awaiting a system command from the teletype.

b. Entering System Command

A system command may be typed whenever the system has just typed a ">". It consists of a command name followed by a maximum of five parameters. The command and parameter fields are separated either by commas or spaces and the entire command is terminated by a "↵".

In the following description of the command formats certain terminology is understood:

1. Any command name may be typed as a single letter, the first letter of the name (i.e., A instead of ASSIGN).

2. The letter "F" in this description represents any file name. A file name consists of from 1 through 6 alphabetic or numeric characters.

3. In all cases where "F" is used below, a common file name of the form "C-F" may be used instead, where C is the name of a common file category. Names of common file categories may be obtained from any member of the CORD staff.

4. The following table is a list of format abbreviations:

   A ≡ Ascii

   PAC ≡ Packed Ascii

   O ≡ Octal

   PR ≡ Program

   C ≡ Core

   T ≡ Teletype

   All of these abbreviations can actually be typed when entering system commands.

5. A non-existent parameter is skipped. No field delimiting commas need be inserted for skipped fields.

6. All numbers used in this description are octal (base 8).

c. System Commands

ASSIGN - assigns a filespace for the user in core, magnetic tape or on teletype.

A, F, α, β, γ , δ

F is the name of the filespace. It must not be the same as any other filespace belonging to the user.

α is the format of the filespace. For a core filespace it may be: A, PAC, O, or PR. For a tape filespace it may be: A, PAC, O. For a teletype filespace it may be: A.

β is the medium of the filespace. It may be: C, T or M (magnetic tape) for which the tape reel number must also be specified. Mn, where n is the tape reel number. For a core filespace, γ specifies the first address of the filespace relative to the beginning of the user's workspace. δ specifies the number of words in the filespace. For a tape filespace that is simply a string of words, γ is the maximum number of words in the filespace and δ is non-existent. For a tape filespace that is a string of records, γ is the number of records and δ is the maximum number of words per record. There may be assigned a maximum of 377 records. Maximum record length is 200 words. The maximum number of words in any tape filespace is 77600. For a teletype filespace α, γ and δ are non-existent. The ASSIGN serves to assign a symbolic name to the teletype.

Note that the allocation of space for programs and data is done in terms of filespaces, private or public. Into a filespace may be moved a file, providing its length is no longer than the filespace. A move command copies only the file--the actual data--within the named filespace.

KILL - kills or deletes a filespace from the system.

K, α

α is the name of the filespace.

Reference to a killed filespace evokes the same response as if the file had never been assigned.

MOVE - moves or copies the contents of one filespace into another.

M, α, β, γ, δ

For a move of an entire filespace to another, α is the name of the filespace from which data is being moved. β is the name of the filespace to which data is being moved. γ and δ are non-existent. For a move of a record to an entire filespace, α is the name of the filespace from which data is being moved. β is the number of the record to be moved. γ is the name of the filespace to which data is to be moved. δ is E (for entire). For a move of an entire filespace to a record of another, α is the name of the filespace from which data is being moved. β is E. γ is the name of the filespace to which data is being moved. δ is the number of the record to which the data is being moved.

To be executed, the filespace or record which is being moved must contain a file of length less than or equal to the length of the filespace or record into which the data is to be moved.

Only magnetic tape files have the record-type move capability.

For a move from teletype to core or magnetic tape, either of two means may be used to terminate the teletype input. Either sufficient data is typed to fill the filespace to which data is being moved or an "am" or "ctrl A" key can be depressed.

LIST - lists or prints the name, format, medium and other information of all filespaces belonging to the user.

L, α

For a list of all private files of the user, α is non-existent. For a list of all common files in any category, α is the name of that category.

WORKSPACE - obtains a contiguous section of core memory for the user.

W, α

α is the number (octal) of words the user needs for his program and data in core. If α is 0 (zero) any core space he had is returned to the system.

Execution of a W automatically does a W, 0 first, so that anything in core must be stored on tape before an attempt to obtain a larger area of core.

READ - reads from teletype into specified locations in the user's workspace without the necessity of assigning filespaces.

R, α, β, γ

α is the first address into which data is to be entered (relative to the beginning of the workspace). β is the maximum number of words to be read. γ is the mode of input. The mode may be:

a) O, octal

b) PR, program (all words are relocated relative to the workspace)

c) A, ascii (one character per word)

d) PAC, packed ascii (6 characters per word)

At any time an "am" (alt. mode) character depressed on the keyboard will terminate the command. Likewise, input of a non-octal character during an O or PR read terminates the command after the following carriage return.

The format for an octal read is shown in the following examples:

	goes in as
+7 ↵	+000000000007
61 ↵	+000000000061
-4324 ↵	-000000004324
463+5731 ↵	+000000005731
A62-3746045 ↵	-000003746045
AD63 ↵	+0 (and terminates)
*7,6,-43 ↵	+000000000007 +000000000006 -000000000043

*This optional format is legal only when used in conjunction with moves associated with magnetic tape filespaces.

For an A or PAC read most characters are legal.

For all types of read, the "ctrl L" character or "\" backspaces one character:

43 \ 6 → 46

627 \\ 414 → 6414

The " ← " character causes all input to be disregarded since the last "↘". The "ctrl A" character terminates the read immediately as does the "am" (alt. mode).

PRINT - prints on teletype from specified locations in the user's workspace.

P, α, β, γ

α is the first address from which data is printed (relative to the beginning of the workspace). β is the maximum number of words to be printed. γ is the output mode and may be:

a) 0

b) PR

c) A

d) PAC

While a print is in execution, depression of the "am" key causes its immediate termination.

GO - initiates execution of the program in the user's workspace at the specified location.

G, α

For program initiation at any location within the workspace α is the address of the first instruction to be executed. For the program to continue where it last halted, α is non-existent.

DUMP - dumps or prints the contents of the registers associated with the user's program.

D, α

To dump any index register α is:

I1 for index register 1

I2

•

•

•

I7 for index register 7

To dump the A register, α is A.

To dump the Q register α is Q.

To dump the value of the program counter relative to the user's workspace, α is PC.

To dump the number of words in the user's workspace, α is W.

QUIT - logs user off system.

Q

This command halts any program belonging to the user that may have been running, executes a W, 0 and logs the user off the teletype console. To again activate the console the login procedure must be followed.

d. Program Execution

To initiate execution of any program the user must first have obtained a workspace. A program must then be loaded by a READ or MOVE command. Then a GO command begins execution.

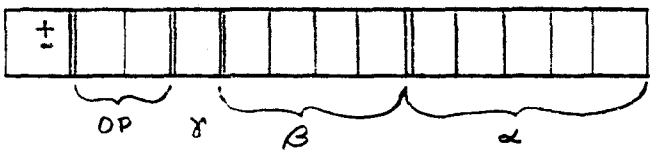
Once the program is started, control of the teletype is relinquished to the program. It may, by appropriate execution of system commands, cause teletype input/output.

To return control to the user at any time, depress the "am" key. This action halts the program execution and causes CORD to prepare for input of a system command from the teletype.

II. USER PROGRAMS

a. User Program Machine Instruction Format

The format of instructions in a user program is:



Each block in this diagram is an octal digit (3 bits) except for the sign (1 bit: 1 if -, 0 if +).

The OP field specifies the two digit operation.

γ specifies an index register 1-7 or is 0 if the operand is not indexed.

α is the address of the operand (indexed by γ).

β has significance for the TRI and some system commands.

Certain operations marked by an asterisk (*) in the following User Program Operation Codes take considerably longer to execute than others, due to the hardware-software system protection mechanism built into CORD. Other operations than these should be used when possible to speed up program execution.

b. USER PROGRAM OPERATION CODES

Code	Mnemonic	Description
10	CLA	$(\alpha) \rightarrow A$
14	CLS	$-(\alpha) \rightarrow A$
11	CAM	$1\ (\alpha)\ 1 \rightarrow A$
15	CSM	$-1\ (\alpha)\ 1 \rightarrow A$
*50	STR	$A \rightarrow (\alpha)$
*51	LOD	$(\alpha) \rightarrow$ reg β**
12	ADD	$A + (\alpha) \rightarrow A$
16	SUB	$A - (\alpha) \rightarrow A$
13	ADM	$A + 1\ (\alpha)\ 1 \rightarrow A$
17	SBM	$A - 1\ (\alpha)\ 1 \rightarrow A$
20	MLY	$Q \times (\alpha) \rightarrow A, Q$
21	MLR	$Q \times (\alpha) \rightarrow A$
32	SHR	Shift A right α bits
30	SHL	Shift A left 2 bits
31	SLL	Shift A, Q left α bits
03	LGA	A log add $(\alpha) \rightarrow$ A (or)
02	LGM	A log mult $(\alpha) \rightarrow$ A (and)
04	LGN	Complement $(\alpha) \rightarrow$ A (1's comp.)
*40	TRU	Transfer unconditionally to α
*45	TRZ	Transfer if $\lvert A \rvert = 0$ to α
*46	TRN	Transfer if sign A = "-" to α
*44	TRP	Transfer if sign A = "+" to α
*57	TRY	$IX_Y - 1 \rightarrow IX_Y$; (see note A) then if $IX_Y \leq 0$, $PC + 1 \rightarrow PC$ else $(\alpha) \rightarrow PC$
*53	TRI	$IX_Y + 1 \rightarrow IX_Y$; then if $IX_Y \geq (\beta)$, $PC + 1 \rightarrow PC$ else $(\alpha) \rightarrow PC$
*54	TSX	$PC + 1 \rightarrow IX_Y$; $(\alpha) \rightarrow PC$
00	HLT	Halt - user program, not actual computer

User Program Operation Codes (continued)

**registers specified in β can be:

0001	IX1
0002	IX2
0003	IX3
0004	IX4
0005	IX5
0006	IX6
0007	IX7
0010	Accum
0011	Q

registers specified in α can be:

*70000	plus zero
70001	IX1
70002	IX2
70003	IX3
70004	IX4
70005	IX5
70006	IX6
70007	IX7
70010	Accum
70011	Q

*fetch only, cannot be written into.

For all instructions having as operand address a location in the workspace, the sign of the instruction must be - . This informs the system that relocation with respect to the workspace is necessary. The shift commands, the 33 and the 56 teletype I/O command must have + signs.

All operations except TRY, TRI and TSX may be indexed (address modification). The contents of IX_γ are added to the instruction before it is executed. Beware of unpredictable instruction modification if an index register does not contain zeroes in the op, γ and β fields.

Note A: The TRY instruction decrements (IX_γ) regardless of its sign. If $(IX_\gamma) = 0$, it is not decremented and PC + 1 $\rightarrow$ PC.

c. CORD Command Vectors

Several system commands can be called by a user program by execution of a 33 operation. The calling instruction has as its operand address a pointer to the first word of a command vector.

The first (0^{th}) word of the vector is the command number and the remaining words are parameters. Since commands require different numbers of parameters, the length of the vector varies from command to command. All vector entries are right justified in the words.

Command		Vector
ASSIGN		0. 1
		1. a) if cat. file, cat. no.; b) if not, 0
		2. file name
		3. format
		4. medium
	tape	5. a) if simple file, no. words; b) if rec., no recs.
		6. a) if simple file, 0; b) if rec., no words per rec.
	core	5. 1st address of file rel. to workspace
		6. no. words in file

A simple file is a string of words. A record-oriented file is a string of records, each containing a string of words.

Format Options	Medium Options
22 ascii	01 core
55 octal	05 teletype
65 PAC	11 display
67 program	04mmm mag. tape (mmm is tape reel number)

KILL	0. 13	
	1. a) if cat. file, cat. no.; b) if not, 0	
	2. file name	

Command	Vector	
MOVE	0. 15	
	1. a) if cat., cat. no.; b(if not, 0	file moved from
	2. file name	
	3. a) if entire, 0; b) if rec., rec. no.	
	4. a) if cat., cat no.; b) if not, 0	file moved to
	5. file name	
	6. a) if entire, 0; b) if rec., rec. no.	
PRINT	0. 20	
	1. first address	
	2. no. words	
	3. format (same as ASSIGN)	
READ	0. 22	
	1. first address	
	2. max. no. words	
	*3. format (same as ASSIGN)	

*An ascii or PAC read is usually terminated by a ctrl A character. However, if a 7 is placed right justified in the beta field of the format word (word 3 of the vector) a carriage return terminates the command.

HALT	0. 10	
DUMP	0. 4	
	1. register	

register options: 26 ≡ A
27 ≡ Q
30 ≡ PC
3n ≡ IXn (i.e. 31 is IX1)
2 ≡ W (prints no. words in workspace)

The following table shows the moves allowed in the present CORD system.

Media	0--0	0--PR	PR--0	A--A	A--PAC	PAC--A	PAC--PAC	A--0	A--PR	0--A	PR--A
MT--C	X	X		X		X	X				
C--MT	X		X	X	X		X				
TT--C				X	X			X	X		
C--TT				X		X				X	X
TT--MT				X	X			X			
MT--TT				X		X				X	

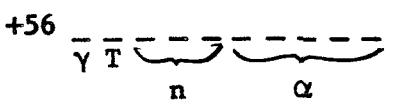
Example of system command call:

```
10:  +330000000020
                    20:  20 print
                    21:  30 address
                    22:   3 no. words
                    23:  55 oct. format
```

This command in location 10 prints 3 words from 30, 31, 32 in octal format.

Shortened Teletype I/O Call

To call for teletype input or output with a single instruction without vector, execute a 56 operation. The instruction is of the form:



α indexed by γ is the relative starting address.

n is the number of words.

T specifies the mode:

```
T:  0  read octal
    1  read ascii
    2  read PAC
    3  read ascii (car. ret. termination)
    4  read PAC (car. ret. termination)
    5  print octal
    6  print ascii
    7  print PAC
```

An example: +560700200010

This instruction prints 2 words of packed ascii from words 10 and 11 of the workspace (relative).

d. Error Returns

Upon completion of a system command called by a user program, control normally returns to the next instruction in the user program. However, if an error occurs--if the calling vector is incorrect or if some malfunction occurs--there may be an error return from the system command call.

Such an error causes program control to be transferred to the user's error return location. Usually, this location is the fourth from the last word of the workspace. When the workspace is assigned to the user a halt instruction is placed there. The user has the option of replacing this instruction by a transfer to an error recovery procedure.

When control transfers to the error return location, the three words following this location contain:

location + 1: location of command call causing error.

location + 2: number of command.

location + 3: error number.

The contents of these locations may be printed out by the user or they may be used by the programmed automatic error recovery procedure.

If the user desires to change the error return location he may execute an ERROR command, giving as parameter the relative address in the workspace to which he would like control transferred. (The error information will be planted in the three words following this address.)

e. Error Numbers

1	Illegal Parameter
4	Illegal Command
5	Input/Output System Error
6	Tape Format System Error
7	Duplicate File
10, 16	FIN Table Full
11	Non-existent File
13	System Error
17	Tape Not Mounted
21	Hash-Sum System Error
22	File Name-Number Conflict System Error
23	Not Implemented
24	Illegal Move
25	Tape File Already Killed System Error
27	Non-Existent Category
31	Non-Octal Format
32	Excessive Input-Last Record Truncated
33	Outside Workspace
43	Referenced Mag. Tape Busy
44	Core File Exceeded
45	FIN Table - Tape Conflict System Error

f. CORD User Processor Internal Character Representations

ASCII		PACKED ASCII
+500000000000	SPACE	40
+502000000000	!	41
+504000000000	"	42
+506000000000	#	43
+510000000000	$	44
+512000000000	%	45
+514000000000	&	-
+516000000000	'	47
+520000000000	(	50
+522000000000	)	51
+524000000000	*	52
+526000000000	+	53
+530000000000	,	54
+532000000000	-	55
+534000000000	.	56
+536000000000	/	57
+540000000000	0	60
+542000000000	1	61
+544000000000	2	62
+546000000000	3	63
+550000000000	4	64
+552000000000	5	65
+554000000000	6	66
+556000000000	7	67
+560000000000	8	70
+562000000000	9	71
+564000000000	:	72
+566000000000	;	73
+570000000000	<	74
+572000000000	=	75
+574000000000	>	76
+576000000000	?	77

ASCII		PACKED ASCII
+600000000000	@	-
+602000000000	A	01
+604000000000	B	02
+606000000000	C	03
+610000000000	D	04
+612000000000	E	05
+614000000000	F	06
+616000000000	G	07
+620000000000	H	10
+622000000000	I	11
+624000000000	J	12
+626000000000	K	13
+630000000000	L	14
+632000000000	M	15
+634000000000	N	16
+636000000000	O	17
+640000000000	P	20
+642000000000	Q	21
+644000000000	R	22
+646000000000	S	23
+650000000000	T	24
+652000000000	U	25
+654000000000	V	26
+656000000000	W	27
+660000000000	X	30
+662000000000	Y	31
+664000000000	Z	32
+666000000000	[	33
+670000000000	\ *	-
+672000000000	]	35
+674000000000	↑	36
+676000000000	← *	37

Carriage Return:
+432000000000 34

Line Feed:
+424000000000 46

Code Delete:
+776000000000 -

Ignore:
+000000000000 00

*Control characters during input may be used only for output.