

pb 250
Cinch Interpreter

PBC 1006
REVISION I.

pb Packard Bell Computer

A SUBSIDIARY OF PACKARD BELL ELECTRONICS
1905 ARMACOST AVENUE • LOS ANGELES 25, CALIFORNIA • GRANITE 8-4247

November 1, 1962

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II. ELEMENTS

A. MEMORY

The CINCH interpretive memory may contain up to 4,095 words. One word is required to represent a command; two words are required to represent a number. The allowable memory addresses are 0000 through 4,095 sequentially provided a sufficient amount of PB 250 memory is available. Each delay line contains 256 locations. It is the programmer's responsibility to confine the program to conform to the size of the particular machine. CINCH will work for any interpretive size memory up to 4,095 words. Address 0000 refers to the accumulator, therefore neither commands nor numbers may be located in 0000. An address specifies the location of a particular number or command in memory. Numbers must always be stored in even numbered locations. Commands may be stored in either even or odd numbered locations.

B. NUMBERS

All numbers used in CINCH must be less than 1.0×10^{38} in absolute value. Larger numbers formed during computation will cause a halt in computation with a line number of 05 displayed. If computation is continued (by restarting) such numbers will be reduced to less than 10^{38} . Numbers smaller in magnitude than 1.0×10^{-38} are set to zero. Each number input to the computer may consist of the following:

- 1) a sign
- 2) up to 10 decimal digits

- 3) a decimal point
 - 4) an exponent and its sign.
- 1, 3 and 4 are optional.

The exponent consists of one or two decimal digits, and specifies the power of ten by which to multiply the number. Every number being input must be followed either by a tab code or a carriage return code.

Examples:

14	6+21 means $+6 \times 10^{21}$
-6317	1.2-14 means $+1.2 \times 10^{-14}$
+2.08	+1+6 means $+1 \times 10^6$
6.8	-1234567-10 means 1234567×10^{-10}

When stored in memory, each number takes up two words. The first word must have an even address and it is the programmer's responsibility to make sure that this is always the case.

If the numbers in the preceding example were stored sequentially starting with location 1000, a decimal representation of memory would appear as follows:

<u>Location</u>		<u>Location</u>	
1000	$+.1400000000 \times 10^2$	1008	$+.6000000000 \times 10^{22}$
1002	$-.6317000000 \times 10^4$	1010	$+.1200000000 \times 10^{-13}$
1004	$+.2080000000 \times 10^1$	1012	$+.1000000000 \times 10^7$
1006	$+.6800000000 \times 10^1$	1014	$-.1234567000 \times 10^{-3}$

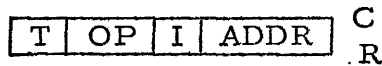
If these numbers were to be printed out, the format would be:

.1400000000+02
 -.6317000000+04
 .2080000000+01
 .6800000000+01

.6000000000+22
 .1200000000 -13
 .1000000000+07
 -.1234567000-03

C. COMMANDS

The command format consists of up to 8 alpha-numeric characters followed by a carriage return. Tabs (and code deletes) are ignored. A command has the form:



TRACE TAG (T)	T if present, space if not present
OP CODE (OP)	2 numeric characters.
INDEX TAG (I)	1 alphabetic character (A-G) if present, space if not present. (The space is not necessary but may be included for format purposes.)
ADDRESS (ADDR)	One, two, three or four numeric characters.
TERMINATION	A carriage return follows each instruction.

Commands are normally performed sequentially, starting with a given location. Certain commands will interrupt the normal sequence and cause control to be transferred out of the normal sequence depending on given conditions. The trace tag, where present, indicates that this command is to be traced during the time the program is being executed if the BREAKPOINT switch is down. The index tag, if present, specifies one of seven index registers lettered A through G. The contents of the base of the specified index register are added to the address of the command to form an effective address for execution. The op code specifies what operation is to be performed. The address, where needed, specifies a memory location which enters into execution of the command.

Examples:

<u>Command</u>	<u>Meaning</u>
10 0126	Clear the accumulator and add the contents of location 0126.
02A1348	Set the base of index "A" equal to the contents of location 1348.
22D0046	If the base of index register "D" contains 0012, then the effective address of this command is 0058 and the command reads: Subtract the contents of location 0058 from the contents of the accumulator.
T42 0319	Transfer to location 0319 if the contents of the accumulator are positive and print the location of this command, the command itself, and the contents of the accumulator.

D. ALPHA-NUMERIC FORMAT

A string of any number of Flexowriter characters, excluding colon (:) and semicolon (;), may be stored, three per word. The termination character which is either a colon or semicolon, is stored in the last word.

Example: TITLE PAGE (requires 4 words)

It is important to remember that spaces, carriage returns, tabs, punctuation marks, upper and lower case shifts, etc., are all characters and must be counted when filling memory with alpha-numeric information. Also remember to count the termination character. A carriage return following the termination character will clear the word following the alpha-numeric data.

E. PROVISION FOR RELOCATION

It may be desirable to write a program with relative addresses so that it may be relocated at will anywhere in interpretive memory. CINCH does this by permitting the programmer to specify the base address for loading the program (S-code) prior to reading it into memory. CINCH will then add the base address, set by the S code, to the address of commands in the pro-

gram. Since there may be commands which will not be relative, an X-code is used to designate non-relative information. The relocation codes are explained in paragraph IV. A.

III. INDEX REGISTERS

The index registers perform a number of important functions. They can be used for "looping", that is, doing iterative operations, counting and tallying, and address modification. CINCH incorporates seven index registers. Each index register consists of a base, a modifier and a limit which can be set and reset separately. When executing an indexed command which is not manipulating the contents of an index register, the base address is added to the command address to give the effective address. The command is left unchanged in memory. For example, if the base of index register "F" was set to 329, then the command

CAD F 0026

would place the contents of location 0355 into the accumulator. The contents of the base of an index register must not be negative.

Sample problem illustrating the use of index register:

Find the sum of all numbers stored in location 0400 to 0450 and store the answer in 0126. The program starts in location 0100.

<u>Location</u>	<u>Program Tape</u>	<u>Symbolic</u>	<u>Remarks</u>
	L0100		Set location.
0100	C02A0108	SIB A0108	Set base = 0000
1	03A0110	SIM A0110	Set modifier = 2
2	04A0112	SIL A0112	Set limit = 50
3	10 0400	CAD 0400	First number

<u>Location</u>	<u>Program Tape</u>	<u>Symbolic</u>	<u>Remarks</u>
4	12A0000	ADD A0402	Next number
5	06A0104	MIT A0104	Increment base of index by 2. Go back to add next number if 0452 has not been reached.
6	60 0126	STA 0126	Store answer when done
7	00 0000	HLT 0000	Stop (finished)
8	D+0	+0	Constants
10	+2	+2	
12	+50	+50	
	E		End of tape signal

IV. INPUT/OUTPUT

A. INPUT

There are two modes of operation, internal and external. After loading CINCH into memory (see Operating Instructions) the computer will be in the external mode. All external (manual) operations are described in Section V.

It is possible to enter information into the computer by way of the keyboard or paper tape. Reading is controlled by one of the external operations R, K, or S (see Section V) or by the RPT or RTK commands. The information read may consist of a combination of the following configurations:

	<u>Code Letter</u>
Alpha-numeric information	A
Commands	C
Decimal numbers	D
Location definitions	L
End of data signals	E
Transfers (Go To)	G
Non-relative address	X

Each configuration is specified by a code letter. When CINCH encounters an A, C, or D it assumes that all following information is of the given type, until another relevant code letter is read. A code letter must follow the termination character for alpha-numeric data. A space in the code letter position, if present, is ignored. A defines alpha-numeric information, C specifies that the following are commands, D denotes data. Types L, E, X, and G are instructional and are not stored in memory. Code deletes are ignored on input.

When the operator makes an error, either in preparing a tape or entering information from the keyboard, the lower case key will reset the datum or command being typed. Commands have two sections, and the lower key will only reset to the start of the section currently being entered. These sections are as follows: (a) everything up to and including the index register designation, and (b) the address. Data has only one section. After typing the lower case key, merely retype the current section.

When a code letter appears on a tape or is typed, the next character to be read must follow immediately. There may be no spaces, tabs, carriage returns, etc., between the code letter and the first data character. Reading of information may be interrupted by one of the instructional code letters. These have the following effect:

Location Setting	Lnnnn	Set location counter and read the following information into memory starting with location nnnn. This code may not appear on a relocatable tape. nnnn may not be 0000.
Go To	Gnnnn	Stop reading inputs and go to location nnnn. nnnn may not be 0000.
End of Data	E	End of data signal. Stop reading inputs and transfer to location following RPT or RTK command, or back to the keyboard if under external control.
Non Relative Address	X	Do not add the contents of the relocation index (set with an <u>S</u> external command) to the address portion of this instruction (this applies only to relocatable programs).

An example of a standard program as it would appear on tape is as follows:
Note the L, C, D, and E codes.

Example:

Find one root of the quadratic:

$$X = \frac{-B + \sqrt{B^2 - 4AC}}{2A}$$

where A, B, and C are stored in locations 0602, 0604, and 0606 respectively, and X will be put in location 0608. If $B^2 - 4AC < 0$ then $X = 0$. The program starts in location 0100.

<u>Location</u>	<u>Program Tape</u>	<u>Symbolic</u>	<u>Remarks</u>
	L0100		Set location
0100	C10 0118	CAD +4	C defines commands
0101	14 0602	MUL A	4·A
0102	14 0606	MUL C	4·A·C
0103	60 0610	STA Temp	Temporary Storage
0104	10 0604	CAD B	
0105	14 0604	MUL B	B^2
0106	22 0610	SUB Temp	$B^2 - 4AC$
0107	41 0114	TAN Neg	Out if $B^2 - 4AC < 0$
0108	57 0000	SQR 0000	$\sqrt{B^2 - 4AC}$
0109	22 0604	SUB B	$-B + \sqrt{B^2 - 4AC}$
0110	15 0120	DIV +2	/2
0111	15 0602	DIV A	$(-B + \sqrt{B^2 - 4AC}) / 2A$
0112	60 0608	STA X	Ans. to X
0113	00 0000	HLT	Stop when done
0114	10 0122 Neg	CAD + 0	
0115	60 0608	STA X	X=0
0116	00 0000	HLT	Stop
	L0118		Set location
0118	D4	+4	Constants
0120	2	+2	D defines data
0122	0	+0	
	E		End of tape, return control to keyboard.

B. OUTPUT

Output of data, commands, or alpha-numeric information may be on either the typewriter or punch. Command format was described in paragraph I. C, and alpha-numeric in paragraph I. D. Numeric data may be output in two forms: as four digit positive integers and as data.

The commands TXT and PXT will type or punch the contents of the base of a specified index register followed by a tab. The number must be positive and less than 4,095. Leading zeros are not suppressed.

Data is output by the commands TNT, TNC, PNT, and PNC and has the form:

$$\pm.nn---nn\pm ee$$

The fractional part of the number (n---n) will contain up to 10 digits preceded by an optional sign and decimal point. The exponent will consist of a sign and two digits.

Ordinarily, ten digits will be typed. However, the SFL command (Set Fraction Length) may be used to designate the number of digits. Note that the number is rounded only in the tenth place. Therefore, if less than ten digits are typed, truncation will occur.

A number is always followed by a carriage return or a tab code, whether printing or punching.

To punch a tape with the PNT or PNC commands that may later be read by the RPT command, the programmer must ensure that there is a "D" on the tape preceding the first piece of data punched. This can be accomplished either manually or by the PAC command.

Examples of input data tape:

L1000
D+123.456
-1.234+02
1.2345-03
1234567-10
E

This tape stores data in the interpretive memory as follows:

<u>Location</u>	<u>Data</u>
1000	+ .1234560000 x 10 ³
1002	- .1234000000 x 10 ³
1004	+ .1234500000 x 10 ⁻²
1006	+ .1234567000 x 10 ⁻³

If the contents of the preceding locations were printed by the TNC command, they would appear as follows:

.1234560000+03
- .1234500000+03
.1234500000-02
.1234567000-03

There are no instructions to type or punch command format, but this is possible by external control. See the description of the M external operation in Section V for further details.

C. TRACING

If the BREAKPOINT switch is down, all commands with a trace tag will be printed. In addition, the location of the command and the base of the specified index register if any, will be printed as 4 digit numbers. The contents of

the accumulator after execution of the command, will be printed in data format. Example:

```
1037    T41C0167    0013    +.1234514239-14
```

After the Enter Trace Mode (ETM) command is performed, all subsequent commands (with or without a trace tag) will be traced if the BREAKPOINT switch is down. This condition prevails until a Leave Trace Mode (LTM) command is performed. Blocks of instructions, or a whole program, may thus be traced without recourse to the trace tag.

V. EXTERNAL OPERATIONS

After CINCH has been loaded into memory the computer will be in external mode. The light on the Flexowriter will come on and the computer will be ready for one of the nine external operations. See Appendix B for a further description of External Operations.

It is possible to transfer to external mode at any time by depressing the ENABLE switch. The parity must then be cleared with the BREAKPOINT switch. Depressing the "I" key on the Flexowriter keyboard, and raising the ENABLE switch will effect the transfer of control. The Flexowriter light will come on and a series of characters may be typed to prepare CINCH for one of several functions. These are as follows:

Read Standard or
Binary Tape

R

Read a tape punched in standard input or binary format, (containing commands, data, alpha-numeric information, etc.). The code letter E on a standard tape returns control to the keyboard for another external operation. The binary tape must have been previously punched by CINCH. In this case, control will return to the keyboard if the check sum compares. If not, the computer will halt with a line number of 03. Clearing parity will return control to the keyboard.

Punch Binary Tape

P

The operator must type an initial address, space, and a final address, followed by a carriage return. The information located in memory between these addresses will be punched out in 8-bit binary. Control is returned to the keyboard.

Read Standard Keyboard	K	Read the keyboard in standard input format. The operator may then type any information (as described in paragraph IV. A. The code letter E will return control to the keyboard for another external operation of the type described in this section.
Read Relocatable Standard Tape	S	The operator must type an address followed by a carriage return. The relocation base address will then be set to this address and a relocatable tape will be read. The code letter E on the tape returns control to the keyboard. The address may not be 0000.
Go To	G	Control will transfer to the location currently in the program counter. This code is used to exit from external control or to resume full speed operation after single stepping.
Set Program Counter	\$	The operator must type an address followed by a carriage return. This sets the program counter to the location given. The next command executed (for example under single step mode or following a "G") will come from this location. The address may not be 0000.
Single Step	Z	Perform the next command. Initially, the program counter must be set by the \$ external operation. Each time the Z key is depressed, the computer will execute one command and advance the program counter. Control remains with the keyboard.
Type Program Counter	Q	The computer will type the contents of the program counter. The address shown will be that of the last command performed, unless that command was a transfer, in which case it will be the location of the next command. When

single stepping, the program counter contains the address of the next command to be executed.

Memory Print Out M

The operator must type an initial address, a space, and a C or D. The information in the location specified will be typed out in either Command (C) or Data (D) format. If the BREAKPOINT switch is down, only one location will be typed. If the BREAKPOINT switch is up, sequential locations will be typed out until the switch is depressed. If the address of 0000 is given, only the contents of the accumulator will be typed in Data format. The D should not be typed.

After typing, control is then returned to the keyboard for another external operation.

Listable tapes (standard input format) may be produced by turning the punch on while executing a memory printout. The information will simultaneously output on the keyboard and punch.

If the tape being punched is to be read back into CINCH, then the operator must also punch a C or a D on the tape immediately preceding the first command or piece of data, and a G or an E at the end of the tape.

Index Register Y

The operator must type the desired index register (A-G) followed by a space, tab, or carriage return. The current base and limit of the specified index register will be typed. Control is returned to the keyboard for another external operation.

VI. COMMAND LIST

A. INTRODUCTION

The following is the complete list of available commands. AC refers to the accumulator. Sw is a switch used by CINCH. () refers to the contents of the named location enclosed in parentheses. The address portion of all commands with the exception of those referring to an index register are indexable. Where the index position, i, is specified, it is an integral part of the command and must be given. M refers to any word in memory, including the AC (address = 0000), and specifies the address used in performance of the command.

B. ARITHMETIC

CAD	M	<u>Clear and Add</u>	(10)
		Clear the AC and add (M) to the (AC). (M) are unaffected.	
CSU	M	<u>Clear Subtract</u>	(20)
		Clear the AC and subtract (M) from the (AC). (M) are unaffected.	
CAA	M	<u>Clear Add Absolute</u>	(11)
		Clear the AC and add the absolute value of (M) to the (AC). (M) are unaffected.	
ADD	M	<u>Add</u>	(12)
		Add (M) to (AC). The result replaces (AC). (M) are unaffected.	
ADA	M	<u>Add Absolute</u>	(13)
		Add the absolute value (M) to (AC). The result replaces (AC). (M) are unaffected.	

SUB	M	<u>Subtract</u>	(22)
		Subtract (M) from (AC). The result replaces (AC). (M) are unaffected.	
MUP	M	<u>Multiply</u>	(14)
		Multiply (AC) by (M). Result replaces (AC). (M) are unaffected.	
DIV	M	<u>Divide</u>	(15)
		Divide (AC) by (M). Result replaces (AC). (M) are unaffected. If (M) = 0, the computer halts, with a line number of 06.	
DVM	M	<u>Divide Memory</u>	(25)
		Divide (M) by (AC). The result replaces (AC). (M) are unaffected. If (AC) = 0, the computer halts with a line number of 06.	
FIX	M	<u>Fixed Output Mode</u>	(61)
		Convert (AC) to fixed point output mode. All succeeding print-out commands will allow a maximum of M digits before the decimal point. CINCH will remain in this mode until changed by either a Floating Output Mode (FLO) or another FIX command.	
FLO		<u>Floating Output Mode</u>	(62)
		Set (AC) to floating point output mode. All succeeding output will be in floating point. (AC) will remain in this mode until changed by a FIX command.	

C. INDEX REGISTERS

SIB i	M	<u>Set Index Base</u>	(02)
		Set the base of index i to (M). (M) are unaffected.	
SIM i	M	<u>Set Index Modifier</u>	(03)
		Set the modifier of index i to (M). (M) are unaffected.	
SIL i	M	<u>Set Index Limit</u>	(04)
		Set the limit of index i to (M). (M) are unaffected.	

MIT i M Modify Index and Transfer (06)

The modifier of index i (m_i) plus the current value of the base of i (b_i) becomes the new value of b_i . If the new b_i has not passed the limit of i (L_i) then control is transferred to M. Otherwise the range is satisfied and control continues in sequence. This condition can be explained as follows:

$b_i = b_i + m_i$. If $m_i \geq 0$ and $b_i \leq L_i$ then transfer is to M.

If $m_i < 0$ and $b_i \geq L_i$ then transfer is to M.

Otherwise no transfer occurs and the program continues sequentially. M may not be 0000.

D. MANIPULATION AND TRANSFER OF INFORMATION

STA M Store Accumulator (60)

Store (AC) in M. The (AC) are unaffected. The original (M) are destroyed. M may not be 0000.

STBi M Store Index Base (05)

Store base of index i in M. The base is unaffected. The original (M) are destroyed. M may not be 0000.

E. DECISIONS AND TRANSFERS

TRU M Transfer Unconditionally (40)

Transfer control to M. The next command will be executed from location M. M may not be 0000.

TAN M Transfer Accumulator Negative (41)

Transfer control to M if $(AC) < 0$. Otherwise continue in sequence. M may not be 0000.

TAP M Transfer Accumulator Positive (42)

Transfer control to M if $(AC) \geq 0$. Otherwise continue in sequence. M may not be 0000.

TAZ M Transfer Accumulator Zero (43)

Transfer control to M if $(AC) = 0$. Otherwise continue in sequence. M may not be 0000.

TNZ	M	<u>Transfer on Non-Zero</u>	(44)
		Transfer control to M if (AC) \neq 0. Otherwise continue in sequence. M may not be 0000.	
CAM	M	<u>Compare Accumulator and Memory</u>	(30)
		Set sw = (AC) - (M). (AC) and (M) are unaffected.	
TCL	M	<u>Transfer if Comparison Switch Low</u>	(31)
		Transfer control to M if sw $<$ 0. Otherwise continue in sequence. M may not be 0000.	
TCH	M	<u>Transfer if Comparison Switch High</u>	(32)
		Transfer control to M if sw $>$ 0. Otherwise continue in sequence. M may not be 0000.	
TCE	M	<u>Transfer if Comparison Switch Equal</u>	(33)
		Transfer control to M if sw = 0. Otherwise continue in sequence. M may not be 0000.	
TCU	M	<u>Transfer if Comparison Switch Unequal</u>	(34)
		Transfer control to M if sw \neq 0. Otherwise continue in sequence. M may not be 0000.	
TSI i	M	<u>Transfer and Set Index</u>	(07)
		The base of index i is set with the location of the TSI command and control is transferred to M. M may not be 0000.	
EXT	M	<u>Exit</u>	(45)
		Exit from control of CINCH. This command is used to transfer to a PB 250 machine language program. M is given as a standard CINCH address and the operator must know the actual location this represents. See paragraph VII.C for a complete description of the use of this command.	

F. CONTROL

HLT		<u>Halt</u>	(00)
		Computation stops with a line number 04 displayed and the computer control panel PARITY light comes on. To continue execution of the program the ENABLE and the BREAKPOINT switches must be depressed. Upon raising the ENABLE switch, the program will continue.	

NOP		<u>No Operation</u>	(01)
	No operation is executed. Control continues in sequence.		
ETM		<u>Enter Trace Mode</u>	(21)
	If the BREAKPOINT switch is down, all commands are traced until an LTM operation is encountered.		
LTM		<u>Leave Trace Mode</u>	(23)
	see ETM.		

G. INPUT/OUTPUT

RPT	M	<u>Read Paper Tape</u>	(17)
	Read paper tape prepared in standard input format, into memory, starting with location M. Cease reading upon signal from tape. (See paragraph IV. A.) M may not be 0000.		
RTK	M	<u>Read Typewriter Keyboard</u>	(16)
	Read keyboard in standard input format into locations starting with M until signal from keyboard. (See paragraph IV. A.) M may not be 0000.		
TNT	M	<u>Type Number and Tab</u>	(26)
	Type data word from location M followed by a tab. (See paragraph IV. B.)		
TNC	M	<u>Type Number and Carriage Return</u>	(27)
	Type data word from M followed by a carriage return. (See paragraph IV. B.)		
PNT	M	<u>Punch Number and Tab</u>	(36)
	Punch data word from M followed by a tab. (See paragraph IV. B.)		
PNC	M	<u>Punch Number and Carriage Return</u>	(37)
	Punch data word from M followed by carriage return. (See paragraph IV. B.)		
TAC	M	<u>Type Alpha-Numeric</u>	(46)
	Type alpha-numeric characters starting with location M until <u>;</u> or <u>:</u> is encountered. (See paragraph II. D.) M may not be 0000.		

PAC M Punch Alpha-Numeric (47)

Punch alpha-numeric characters starting with location M until ; or ; is encountered. (See paragraph II.D.) M may not be 0000.

SFL M Set Fractional Length (35)

If (AC) is in the fixed-point mode, this command will set the total number of digits to be typed or punched to M. M may be changed at anytime by another SFL command.

If (AC) is in the floating point output mode, this command will function as follows:

Initially, the TNT, TNC, PNT, PNC commands, the external operation M, and the Trace assume that data is to be typed or punched with a fractional part of 10 digits. This value is permanently changed by M, ($1 \leq M \leq 10$) when this command is executed. The fraction is rounded as if $M = 10$. Therefore, if $M < 10$, the fraction is truncated. Note that M is not an address, but an actual value.

TXT i Type Index Register and Tab (63)

Type the contents of the base of the specified index register as 4 digits followed by a tab. The largest number permitted is 4095.

PXT i Punch Index Register and Tab (64)

Punch the contents of the base of the specified index register as 4 digits followed by a tab. The largest number permitted is 4095.

H. FUNCTIONS

SIN M Sine (50)

Sine (M) replaces (AC). (M) are unaffected. (M) must be in radians.

COS M Cosine (51)

Cosine (M) replaces (AC). (M) are unaffected. (M) must be in radians.

ATN M Arctan (52)

Arctan (M) replaces (AC). (M) are unaffected. (AC) will be in radians.

LNE M Log_e (53)

Log_e |(M)| replaces (AC). (M) are unaffected.

LOG M Log₁₀ (54)

Log₁₀ |(M)| replaces (AC). (M) are unaffected.

EXP M Exponential e^M (55)

e^(M) replaces (AC). (M) are unaffected.

TEN M Exponential 10^M (57)

10^M replaces (AC). (M) are unaffected.

SQR Square Root (56)

$\sqrt{|(M)|}$ replaces (AC). (M) are unaffected.

VII. SUBROUTINES

A. INTRODUCTION

A certain class of programs are called "subroutines". These programs are self-contained units which may be entered repeatedly from various parts of the main program. The return to the main program is usually to the location following the entry command. Two types of subroutines are acceptable to CINCH. These are: CINCH language programs and machine language programs. The more desirable form is CINCH language, which may be used for most subroutines written by the programmer. Machine language should be reserved only for those subroutines whose speed is a critical factor and where the use of CINCH language would be awkward.

B. CINCH LANGUAGE SUBROUTINE

As an example of a subroutine, the programmer may frequently need to compute the tangent of an angle in the program, and this function is not part of CINCH. The programmer may code a routine to evaluate it in CINCH language and store the routine anywhere in memory. By using the TSI command, the operator can enter it from many different places in the particular program.

This command stores its location in the base of the index register specified and then transfers to the address given. In this way, the subroutine "remembers" where it came from and can control its return to the main program at the appropriate location.

For example, assume there is a subroutine to evaluate the tangent of an angle. This subroutine is located in 0124-0175 and expects the argument to be in the accumulator at entry. After evaluation, control returns to the main program with the answer in the accumulator. The last command executed in the subroutine is TRU F 0001. Therefore, to enter this subroutine, the program must have loaded the argument into the accumulator and then given TSI F 0124, which loaded the base of index F with the address of the TSI command and transferred to the tangent subroutine. After evaluation of a tangent the

TRU F 0001

will return control to the command immediately following the TSI command.

Example:

$$X = \frac{a \cdot \text{TAN}(b+c) - d}{\text{TAN } e}$$

Location

1000	CAD b	
1001	ADD c	b + c
1002	TSI F 0124	TAN (b + c)
1003	MUL a	a•TAN (b + c)
1004	SUB d	-d
1005	STA Temp	→ Temp.
1006	CAD e	
1007	TSI F 0124	TAN e
1008	DVM Temp	Temp/ TAN e
1009	STA X	= X

It is frequently desirable to have a subroutine relocatable, that is, coded with only relative addresses so that it may be located anywhere in memory. Of the two types of subprograms acceptable to CINCH, those coded in CINCH

language and those written in machine language, only CINCH language programs may be relocated. CINCH language programs look like standard programs except that the commands with non-relative addresses must be flagged with an X code.

To relocate a given program tape with relative addresses, the operator gives an S external command. This sets the base address for reading the tape. All commands on the tape that do not have an X code as the first character will have the base address added to the address portion of the command as it goes into memory. The X may only be used to protect commands. Data is automatically protected. Where it is necessary for a C and an X to precede the same command, the C must come first.

C. MACHINE LANGUAGE SUBPROGRAMS

It is possible to write machine language subroutines and link to them from CINCH. However, this is a complicated process and the programmer is cautioned to take extreme care in its performance.

The linkage from CINCH to machine language is with the EXT command,

EXT M

where M is a standard, 4 digit, CINCH address. Conversion to the machine language equivalent of this address is accomplished as follows:

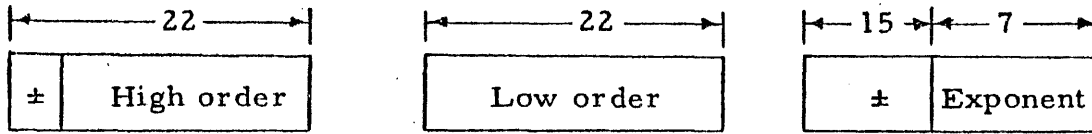
Example: 0139

1. Express address as 12 binary bits: 000010001011
2. 8 low order bits are sector number: 10001011
3. 4 high order bits plus 1100 are line number. (For CINCH I use 1010)

Thus 0139 becomes line 14 sector 213.

The accumulator occupies three words in the short line and has the follow-

ing structure:



The programmer may return to CINCH at anytime, however certain sectors in memory must be restored if line 00 has been disturbed. These sectors are as follows:

001 } 002 }	Accumulator
004	Exponent of accumulator
006	Location counter
015	+0000000

Return to the command following the EXT command by transferring to 345 03.

The programmers machine language segment must be in a command line. If it is necessary to move any command line occupied by CINCH, then the user must restore this line before returning to CINCH.

CAUTION

To avoid possible errors in programming it is essential to exercise extreme care when writing in machine language.

APPENDIX A

SAMPLE PROBLEMS

Sample Program No. 1

Calculate: $P = \frac{0.674 \text{SIN}(y)}{\sqrt{1 - X^2}}$

where $y = e^B - A$ for an unknown number of data sets.

A, B, and X are read from paper tape, the end of data being signalled by G0016.

<u>Location</u>	<u>Program Tape</u>		<u>Symbolic</u>	<u>Remarks</u>
	L0001			Set Location
0001	C17 0018	Z1	RPT	Read A, B, X into 0018, 0020, 0022.
0002	55 0020		EXP B	e^B
0003	22 0018		SUB A	$e^B - A = y$
0004	50 0000		SIN 0000	SIN (y)
0005	14 0024		MUP	0.674 SIN (y)
0006	60 0030		STA Temp	
0007	10 0022		CAD X	
0008	14 0022		MUP X	X^2
0009	60 0032		STA Temp 2	
0010	10 0026		CAD + 1	
0011	22 0032		SUB Temp 2	$1 - X^2$
0012	56 0000		SQR 0000	$\sqrt{1 - X^2}$
0013	25 0030		DVM Temp	$(0.674 \text{ SIN } y) / \sqrt{1 - X^2}$
0014	60 0040		STA P	
0015	40 0001		TRU Z1	
0016	00 0000	Z2	HLT	Stop
	L0024			Set Location
0024	DO. 674		0.674	Constants
0026	1.0		1.0	
	E			End of Program

Data Tape

D (A--)

(B--)

(X--)

E

(A--)

(B--)

(X--)

E

--

--

--

--

(A--)

(B--)

(X--)

G0016

Sample Program No. 2

Table-Look-Up

Find:

$$y = f(x)$$

where x has been previously calculated and stored in location 0100. Let A and B represent two tables of 25 elements each where

$$A_1 \leq X \leq A_{25}$$

If the current value of X is

$$A_i < X < A_{i+1}$$

then

$$y = B_i$$

Table A is stored in locations 0050-0099 and table B is stored in 0150-0199. When completed, store y in 0102 and transfer to location 0135 for the rest of the program.

<u>Location</u>	<u>Program Tape</u>	<u>Symbolic</u>	<u>Remarks</u>
	L0001		Set location
0001	C02F0012	SIB F + 0	Set base of index F = 0
0002	03F0014	SIM F + 2	Set modifier of index F = 2
0003	04F0016	SIL F + 48	Set limit of index F = 48
0004	10 0100	CAD X	X
0005	30F0050	Z1 CAM F A _i	X:A _i
0006	31 0009	TCL Z2	Transfer to Z2 if X < A _i
0007	06F0005	MIT F Z1	Step index and compare A _{i+1}
0008	00 0000	HLT	Error Halt
0009	10F0148	Z2 CAD F B _{i-1}	B _{i-1}
0010	60 0102	STA y	Y = B _{i-1}
0011	40 0135	TRU 0135	Out
0012	D + 0		
0014	+ 2		
0016	+ 48		
	E		End of tape

Sample Program No. 3
Use of Relocatable Subroutine

Calculate:

$$R = \frac{2050 D^2 L}{Q^5 - 1}$$

where $D = \frac{2a}{\sqrt{2-a^2}}$

$$Q = \frac{B}{\log_{10} |k|}$$

$$\text{and } k = \left[\frac{b}{\sqrt{2-b^2}} + b \right]$$

$$L = \frac{a+b}{\sqrt{2-(a+b)^2}}$$

A and B are read from tape. The function

$$\frac{X}{\sqrt{2-X^2}}$$

will be evaluated by a relocatable subroutine which expects the argument to be in the accumulator, and leaves the answer also in the accumulator. Index register 'G' is used by the TSI command which links to the subroutine. The answers will be typed out as drawn including headings.

RUN	A	B	R
0001	.1000000000+01	-.1000000000+01	.0000000000+00

The subroutine appears as follows:

<u>Relative Location</u>	<u>Program Tape</u>	<u>Symbolic</u>	<u>Remarks</u>
0000	C60 0010	STA X	Argument Stored in X
0001	X14 0000	MUP 0000	X^2
0002	60 0012	STA Temp	
0003	10 0008	CAD + 2	
0004	22 0012	SUB Temp	$2 - X^2$
0005	X56 0000	SQR 0000	$\sqrt{2 - X^2}$
0006	25 0010	DVM X	$X / \sqrt{2 - X^2}$
0007	X40G0001	TRU G 0001	Return
0008	D + 2	+2	Constant
0010	0	X	
0012	0	X^2	Temp
	E		

The main program reads a and b into location 0002 and 0004 respectively and expects the subroutine to be locations 0050 - 0063.

The data tape is similar to that in problem number one, with the termination signalled by G0135.

<u>Location</u>	<u>Program Tape</u>	<u>Symbolic</u>	<u>Remarks</u>
	L0100		Set location
0100	46 0160	TAC 0160	Type headings
0101	02C0138	SIB C + 1	Run = 1
0102	03C0138	SIM C + 1	
0103	04C0140	SIL C + 2050	Any large number
0104	17 0002	Start RPT 0002	
0105	10 0004	CAD b	
0106	07 G0050	TSI G 0050	Link to subroutine

<u>Location</u>	<u>Program Tape</u>	<u>Symbolic</u>	<u>Remarks</u>
0107	12 0004	ADD b	$b / \sqrt{2-b^2} + b$
0108	60 0146	STA B	= B
0109	54 0146	LOG B	$\log_{10} B $
0110	25 0146	DVM B	$B / \log_{10} B $
0111	60 0148	STA Q	= Q
0112	10 0002	CAD a	
0113	07G0050	TSI G0050	$a / \sqrt{2-a^2}$
0114	14 0142	MUL + 2	
0115	60 0150	STA D	
0116	10 0002	CAD a	
0117	12 0004	ADD b	a + b
0118	07G0050	TSI G 0050	$(a+b) / \sqrt{2-(a-b)^2} = L$
0119	14 0140	MUL + 2050	2050 L
0120	14 0150	MUL D	2050 LD
0121	14 0150	MUL D	2050 LD ²
0122	60 0152	STA temp	
0123	10 0148	CAD Q	
0124	14 0148	MUL Q	Q ²
0125	14 0000	MUL 00000	Q ⁴
0126	14 0148	MUL Q	Q ⁵
0127	22 0138	SUB + 1	Q ⁵ - 1
0128	25 0152	DVM temp	2050 D ² L / Q ⁵ - 1
0129	60 0006	STA R	= R
0130	63C0000	TXT C	Type run number
0131	26 0002	TNT	Type A
0132	26 0004	TNT B	Type B
0133	27 0006	TNC R	Type R

<u>Location</u>	<u>Program Tape</u>	<u>Symbolic</u>	<u>Remarks</u>
0134	06C0104	MITC start	Run=Run + 1 go to
0135	00 0000 end	HLT	Start
	L0138		Set location
0138	D + 1		Constants
0140	2050		Constants
0142	2		
	L0160		Set location
0160	ARUN		Carriage control func-
0161	(tab) A (tab)		tions are (tab) and (c/r).
0162	B (tab) R		This message contains
0163	(c/r);		11 characters and is
			stored in 0160-0163.
	E		End of tape.

To run the previous problem, the following steps must be performed:

1. Load CINCH I (See Operating Instructions).
2. Set program tape in reader.
3. Type R (under external mode), the program will then load.
4. When the Flexowriter light comes on, set subroutine tape in reader.
5. Type S0050 c/r, the subroutine tape will be loaded into locations 0050-0063.
6. When the Flexowriter light comes on, set data tape in reader.
7. Type \$0100 c/r to set up program counter.

Type G to transfer to the start of the program. When completed, the computer will stop and a line number of 04 will be displayed.

APPENDIX B
OPERATING INSTRUCTIONS

B. OPERATING INSTRUCTIONS

A. LOADING

The procedure for loading CINCH is as follows:

- 1) Insert the CINCH tape at a point somewhere before the first set of holes, into the reader mechanism of the Flexowriter.
- 2) Turn the FILL switch on the Computer Control Panel (see Figure 2-2, PB 250 Technical Manual, Volume 2) to ON position.
- 3) Depress the ENABLE switch on the Flexowriter (see Figure 3-3, PB 250 Technical Manual, Volume 2) and then momentarily depress the BREAK POINT switch to reset the parity flip-flop. Be sure to raise one of these switches after the tape starts moving.
- 4) When the CINCH tape stops, turn the FILL switch to the OFF position.
- 5) The ENABLE switch on the Flexowriter must be depressed while the BREAK POINT switch and "I" key are operated to clear the parity flip-flop and set the computer to obey the first command. When the ENABLE switch is released, computer operation can commence.
- 6) When the check sum compares with the pre-computed value which is stored in the memory, the CINCH tape has been

read in correctly. At this point, the INDICATING LIGHT on the Flexowriter will come on indicating that external control is now possible.

- 7) If the check sum does not compare, the INDICATING LIGHT on the Flexowriter will not come on and a line number of 37_g will appear in the OPERAND indicator of the Computer Control Panel (see Figure 2-2, PB 250 Technical Manual, Volume 2). In this event, steps (1) through (5) must be repeated.

B. OPERATION

Once CINCH has been loaded, any one of the nine external operations may be carried out. These operations are described in the following paragraphs.

1-1. TO READ IN A STANDARD TAPE

Load the tape into the reader mechanism of the Flexowriter. The operator must then type

R

E on the program tape will return control to the keyboard.

Gnnnn on the program tape will transfer control to the location specified by nnnn. Binary tapes may also be read by the R operation.

1-2. TO READ INFORMATION FROM THE KEYBOARD

The operator must type

K

The Flexowriter INDICATING LIGHT will be on, and any combination of standard input information may be typed.

Following the K , the operator must type

Lnnnc/r

(c/r denotes carriage return key)

to set the input location.

a) Commands

The operator must type a

C

followed immediately by one or more commands.

b) Data

The operator must type a

D

followed by one or more numbers in the form described in
Section II, paragraph B.

c) Alphanumeric Information

The operator must type an

A

followed by any alphanumeric string.

d) Termination

When all information has been entered, the operator must type
an

E

or a

Gnnnn

to signal the end of inputs.

Example:

KL0010
C 10 1060
T14A0062
L1060
D+14
-27.6
1.0+6
E

1-3 TO READ A RELOCATABLE TAPE

Load the tape into the reader mechanism of the Flexowriter.
The operator must then type:

Snnnc/r

(c/r denotes carriage return key)

The relocation counter will be set with the address given and the tape will be loaded into memory, starting with location nnnn.

1-4 TO PUNCH A BINARY TAPE

The operator must type:

Piiii Δ ffffc/r

(c/r denotes carriage return key)

where iiii is the initial address, ffff is the final address of the information to be punched out and Δ represents a space or a carriage return. All information necessary for reading the tape into memory with the R operation is also automatically punched on the tape.

1-5 MEMORY PRINT OUT

The memory print out has three options as follows:

- a) To print the accumulator, the operator must type

M0000 Δ

- b) To print memory in command format, the operator must type

Miiii Δ C

where iiii is the first address to be printed. Sequential memory locations will be printed until the BREAKPOINT switch is depressed.

- c) To print in data format, the operator must type

Miiii Δ C

1-6 SET PROGRAM COUNTER

To set the Program Counter, the operator must type

\$nnnnc/r (c/r denotes carriage return key)

The Program Counter will be set to nnnn and the next command will be executed from this location.

1-7 TRANSFER

To transfer from external control, the operator must type

G

when the Program Counter has been previously set with the \$ operation.

Example:

Transfer to location 0149

\$0149

G

1-8 TYPE PROGRAM COUNTER

To print out the contents of the Program Counter, the operator must type

Q

The address shown will be that of the last command executed, unless that command was a transfer, in which case it will be the location of the next command. When single stepping, the Program Counter contains the address of the next command to be performed.

1-9 SINGLE STEPPING

To single step through the program, the operator must first set the Program Counter with the \$ operation (see Paragraph 1-6). Following this operation, the operator must type

Z

Everytime this key is depressed, one command will be executed.

1-10 TYPE INDEX REGISTER

To type the current value of the base and limit of an index register, the operator must type

YIt

where I is the desired index register (A-G) and t is a space, tab, or carriage return. The increment is nontyped.

APPENDIX C
SUMMARY OF EXTERNAL OPERATIONS

Table C-1

SUMMARY OF EXTERNAL OPERATIONS

Type	Operation
R	Read standard or binary tape.
Snnnn T*	Read relocatable tape into memory starting with location nnnn. nnnn may not be 0000.
K	Read standard information from keyboard.
Piiii Δ ffff T*	Punch information between iiii, ffff as 8-bit binary.
\$nnnn T*	Set Program Counter to nnnn. nnnn may not be 0000.
Q	Type contents of Program Counter.
G	Go to location currently in Program Counter.
Z	Single step
Miiii Δ L	Memory print. L may be C or D, specifying Command or Data format. Type information starting in iiii until BREAKPOINT switch is depressed.
YIt	Type Index Register. I may be A-G specifying index register; t may be space, tab, or carriage return.

*T may be a carriage return or space.

APPENDIX D
ERROR HALTS

Table D-1.
ERROR HALTS

OPERAND Indicator shows	Explanation
02	Invalid op code
03	Bad check sum on binary tape
04	Standard HALT command
05	Number formed is greater than 1×10^{38}
06	Division by zero
37	CINCH loaded incorrectly